ELECTRICAL ENGINEERING

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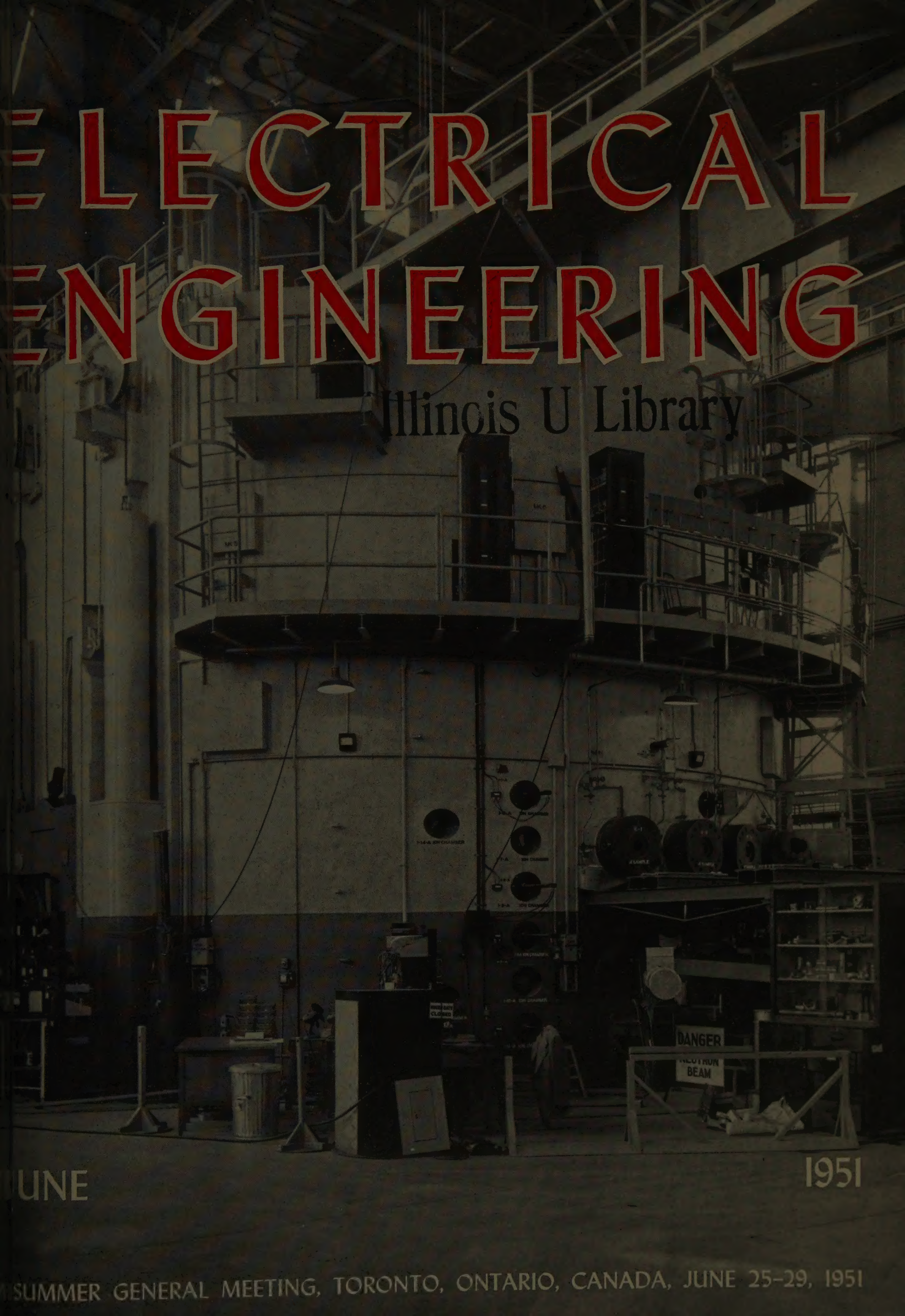

UNE 1951

SUMMER GENERAL MEETING, TORONTO, ONTARIO, CANADA, JUNE 25–29, 1951

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CURVACORE Transformer Producti

IT IS NOW EASIER to obtain *Curvacore* distribution transformers. Production facilities are expanded. You'll be able to take advantage of the inherent benefits of *Curvacore* transformers sooner.

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transformers are 25 kva an
Others will be available shortl

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ELECTRICAL ENGINEERING

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JUNE
1951

The Cover: One of the uses of the Chalk River N.R.X. Nuclear Reactor is as a research reactor in the sense that the radiations can be used for technological research for atomic-energy purposes and for pure research in physics and radioactive chemistry (see story on pages 476–8).

National Research Council of Canada photograph

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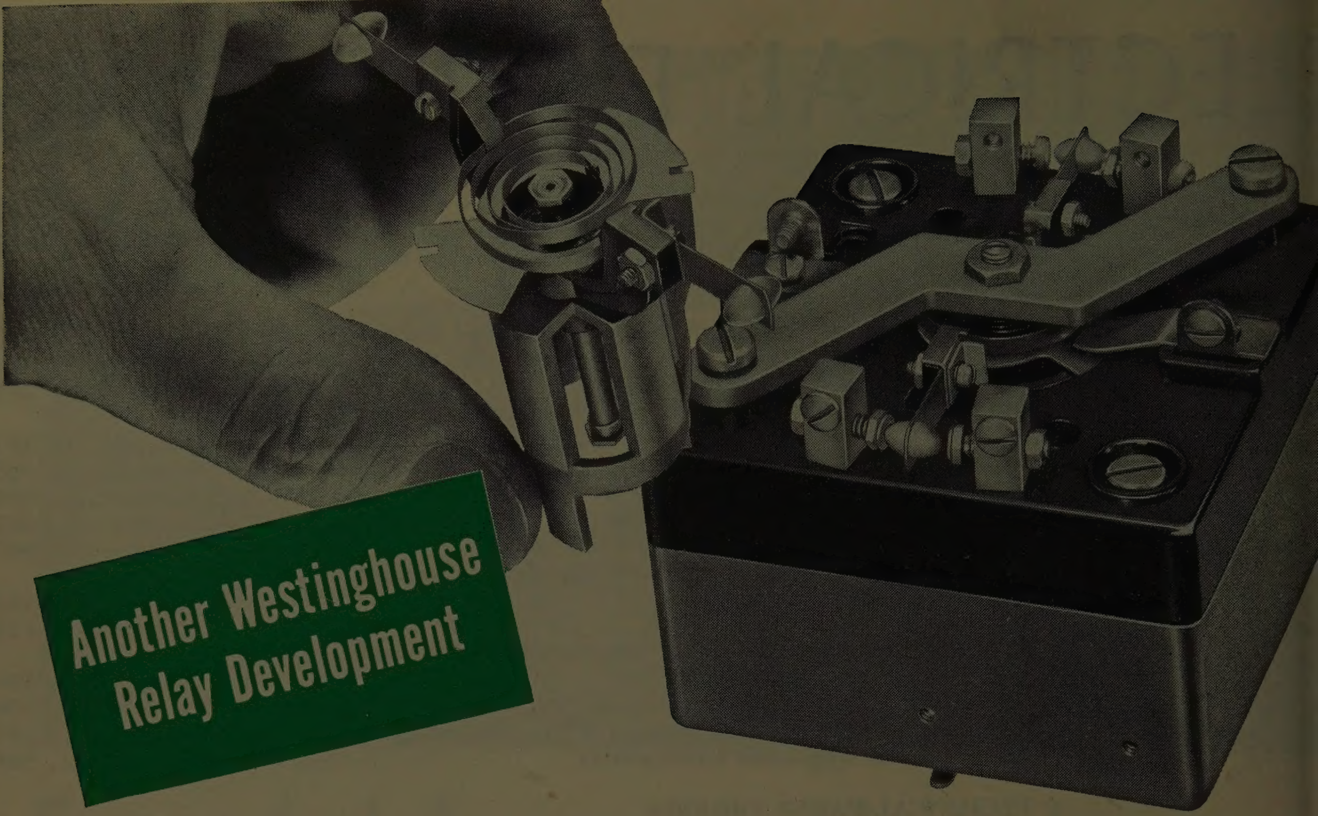
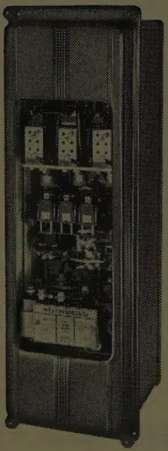


New double-loop directional element ELIMINATES VIBRATION...



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HIGHLIGHTS........

Reminder: If you have not returned your Technical Division Publications questionnaire yet, please do so as soon as possible. See story on page 550 of "Institute Activities" for further details.

Multiple-Unit Car Equipment. An article describing a new a-c multiple-unit car equipment recently placed in service on the electrified lines of the Pennsylvania Railroad discusses the fundamental reasons for its selection and reviews developments now in progress which offer the prospect of further economies (*pages 471–75*).

Chalk River N.R.X. Nuclear Reactor. The functioning of this Canadian experimental nuclear reactor is illustrated in this article by a schematic analogue. Neutrons from the reactor have been used for a study of their radioactive decay and a re-evaluation of their mass; also the energies and intensities of gamma rays emitted on neutron capture have been measured (*pages 476–78*).

Radio-Influence Tests. Measurements have been made of the radio-influence causes by very-high-voltage transmission lines. These tests, conducted at the 500-kv test project of the American Gas and Electric Company, were conducted to aid in the designing of new high-voltage systems (*pages 481–86*).

Structure and Properties of Ferrites. This article, by Dr. F. G. Brockman of Philips Laboratories, Inc., begins with a review of the crystal structure of ferrites, then goes on to discuss the recent advances in the theory of ferromagnetic ferrites. Néel methods are followed in the discussion of the Néel theory (*pages 489–94*).

Frequency Compensation of A-C Instruments. A general solution for one type of voltmeter compensation for a frequency variation is presented this month. Because the meters have an inherent inductance they will read low as frequency is increased; by rigorous analysis of the meter network a compensating capacitance may be added which will increase the possible use of the meter (*pages 494–97*).

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Application of Microwave Channels. Many power companies and other industries are establishing microwave systems in their communication networks. A discussion of the practical problems involved in the design of such a system is presented by R. C. Cheek of the Westinghouse Electric Corporation (*pages 500–03*).

Mathematics in Electrical Graduate Education. It is the responsibility of college faculties to see that the needs, general and common, of their students receive careful consideration. Mathematics courses which fulfill some of these needs should be taught by those trained in the field of applications (*page 507–10*).

Economics of Power Transformer Application. The economic factors which must be considered in the installation of a new power transformer are covered this month. They include comparison of single-phase and 3-phase transformers, transformer insulation level, types of cooling, and selection of method of cooling (*pages 512–16*).

Germanium Trigger Photocells. A versatile newcomer to the growing list of photoelectric transducers is the germanium photocell. In addition to its operating itself as a relay, it will operate an electromechanical relay and so actuate large-scale systems such as alarms or motors (*pages 518–20*).

Lightning-Arrester Characteristics and Location. A study has been made of the change in station apparatus protection which occurs with a change in lightning-arrester characteristics or location. To make the test 97-kv valve lightning arresters and various capacitors were connected to one end of a test line and an impulse generator was discharged into the other (*pages 524–28*).

Large Electronic Power Source. A power source has been developed for use with d-c contact testing equipment. Using electronic tubes, this source eliminates the need for large rotating equipment and provides up to 10,000 amperes at 250 volts (*pages 530–32*).

Instant Starting of Fluorescent Lamps. The trend toward instant starting of fluorescent lamps has been a challenge to designing engineers in the circuit, ballast, and lamp activities. Results to date show considerable progress in reduction of ballast size, weight, and cost while over-all efficiency has increased. Possibilities for further improvement of the lamp and auxiliary combinations are discussed to indicate probable future trends (*pages 533–38*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions.*

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Jul '50, p 30A	Winter General North Eastern District Great Lakes District Summer and Pacific General
Nov '50, p 44A	Middle Eastern District Fall General
Mar '51, p 35A	Winter General

The Canadian Approvals Laboratories. This Canadian counterpart of the Underwriters' Laboratories was first authorized in the Province of Ontario and now has interprovincial acceptance. This should interest United States engineers responsible for the design and manufacture of apparatus for sale in Canada (*pages 538–40*).

In "A Study of Nuclear and Electronic Magnetic Resonance" by K. K. Darrow, *Electrical Engineering*, May, pages 401–04, credit for the illustrations should have been given to E. M. Purcell, Harvard University, for Figure 1, and to R. M. Bozorth, Bell Telephone Laboratories, for Figure 2.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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WESTON *Instruments*

Multiple-Unit Car Equipment for A-C Electrified Railways

H. G. JUNGK
MEMBER AIEE

W. M. HUTCHISON
MEMBER AIEE

S. E. NEWHOUSE

SUBURBAN commuter traffic has been a problem to the railroads of the country for a long time. The nature of the traffic creates a heavy volume for a imited period during morning and evening rush hours. For the rest of the day a large portion of the equipment is dle. As a result, the fixed charges are a relatively high percentage of the total cost of providing this service to the commuter.

It has long been recognized that the electric multiple-unit car is an ideal means for handling suburban traffic. It has advantages in operating flexibility, in relatively high rates of acceleration as compared to locomotive-hauled trains, and in practically uniform accelerating rates regardless of the length of train provided a constant ratio of motor cars to trail cars is maintained.

This description of the latest a-c multiple-unit car equipment to go into service on the Pennsylvania Railroad reviews the features which have been incorporated to provide motors and control at a reasonable cost, with adequate margin for the service, and which are expected to result in major economies in operation over the years. The possibility of reducing costs of multiple-unit cars by the use of Ignitron-rectifier motive power to effect standardization of traction also is discussed in this article.

However, electrification is expensive, and it is important that further progress be made in reducing costs not only f additional extension of electrification is to be considered but also to obtain a reasonable return from this service on those now in operation.

For these reasons, three important objectives to be sought n new multiple-unit cars are ow initial cost, simplicity, and low maintenance expense. Low initial cost is important to reduce the fixed charge content of the total cost of operation. Simplicity of construction and circuits is necessary to assist in achieving low maintenance without which no operation can be economical.

There recently have been placed in service on the Pennsylvania Railroad new a-c multiple-unit cars, the equipment for which was developed to meet these important bjectives. This equipment includes two Westinghouse ype-*431-A* resistance-lead motors, connected permanently n parallel, and electropneumatic control arranged to provide automatic acceleration at one mile per hour per econd for operation, without trailers, in multiple with xisting cars. Dynamic braking is not included. It was designed after a careful analysis of several types, each with individual merit, which might be used for multiple-unit cars. Several of the major alternates considered include the number of motors per car, trailer or all motor car operation, and the use of dynamic braking.

NUMBER OF MOTORS PER CAR

WITH A 4-motor equipment, the total car weight is distributed over four driving axles, permitting application of relatively high tractive force without slipping the wheels. This makes possible higher accelerating rates than can be used effectively on 2-motor equipments. While this feature is desirable to maintain schedules for the short runs typical of local subway service, high accelerating rates for the longer runs common in commuter service result in little improvement in schedule speeds with a relatively large increase in power consumption. The particularly attractive feature of a 4-motor equipment is its adaptability to cushioned mounting of the motors on the truck. By subdividing the required motor capacity into four units instead of two, there usually is adequate space in the car trucks sufficient for the motors and the drive elements required for truck mounting. This is more difficult where two larger motors are used per car. The advantages are reduction of road shocks transmitted to the motors, better alignment and lubrication of gears and pinions, and an improved ride for the passengers.

However, there are disadvantages. Fundamentally, four small motors can be expected to cost more than two larger motors if they are designed for the same service and with the same margin in capacity. The four gear-drive units, together with the flexible couplings, can be expected to cost more than the two sets of gears and pinions for two axle-hung motors. The closer tolerances which must be maintained with the gear unit and coupling require a higher grade of maintenance, or without it, more frequent attention. Car wiring is more expensive with both trucks motorized instead of only one. Maintenance of four smaller motors instead of two larger ones is normally more. The motors and their principal parts, in either case, are too large to be handled without crane facilities. There are twice as many armatures, stators, commutators,

---

omposite digest by W. M. Hutchison of three papers: **51-36**, "A New Multiple-Unit Car Motor for the Pennsylvania Railroad," by H. G. Jungk; **51-104**, Selection of Equipment for Multiple-Unit Cars," by W. M. Hutchison; and **51-05**, "New A-C Multiple Unit Car Control for the Pennsylvania Railroad," by S. E. ewhouse, recommended by the AIEE Committee on Land Transportation and pproved by the AIEE Technical Program Committee for presentation at the IEE Winter General Meeting, New York, N. Y., January 22–26, 1951. All are heduled for publication in AIEE *Transactions*, volume 70, 1951.

. **G. Jungk, W. M. Hutchison,** and **S. E. Newhouse** are with Westinghouse Electric orporation, East Pittsburgh, Pa.

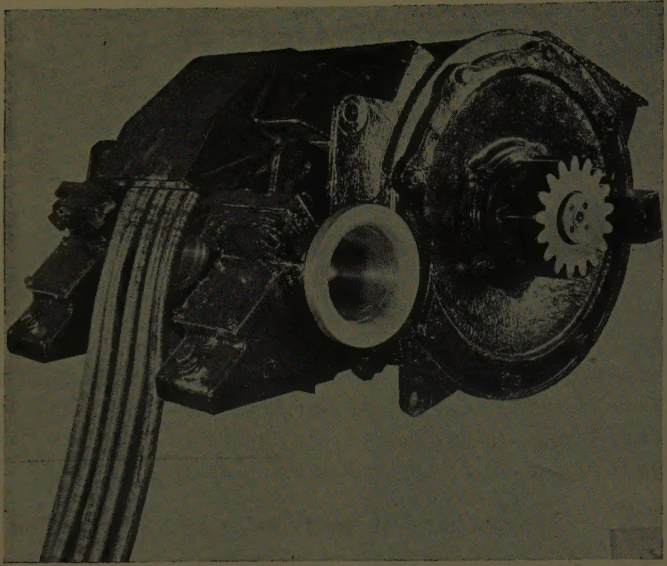


Figure 1. Type 431-A motor—view from pinion end

brushholders, and many detailed parts. A careful consideration of these features led to the selection of a 2-motor equipment.

TRAILER OPERATION

With electric multiple-unit cars, three methods of operation are possible—all motor cars, semipermanently connected 2-car units consisting of one motor car and one trailer, and motor car and trailer operation in varying make-up of trains limited to a minimum fixed ratio of motor cars and trailers. Each has its advantages, and all are in use successfully.

The most economical method of operation is the largest possible use of trailers during the rush hours to reduce the investment for equipment which has a poor load factor, and the use of all motor cars during the nonrush hours to provide the fastest service to attract new patrons. However, motor-car-and-trailer operation gives the least amount of flexibility. All-motor-car operation requires a minimum of terminal switching and affords the greatest protection of equipment and schedules in case of failure of one car in a train.

Most postwar purchases have specified all motor cars. The relative economies of low fixed charges obtainable with trailer operation have been weighed against the high operating flexibility of all motor cars. This has led to the conclusion that the additional investment for all-motor-car operation is justified by the reduction in terminal facilities and costs.

DYNAMIC BRAKING

Dynamic braking has been widely used in city, rapid transit, and locomotive service, but no applications have been made in the United States in multiple-unit commuter service. There is no fundamental reason why it should not be used. It is again simply a question of whether the results obtained from its use justify the additional cost and complication.

The benefits to be expected are reduction in brake shoe dust, lower wheel temperatures, and savings in brak shoes—the latter variously estimated at $50 to $250 per ca per year.

However, its use requires special provision in the desig of the motor of sufficient capacity to obtain full servic braking from high speeds. It also involves additional control equipment. The additional costs and complicatio have so far militated against its use on suburban cars.

RESISTANCE-LEAD MOTORS

Having determined that a 2-motor equipment withou dynamic braking and with all cars motorized wa well adapted to meet the fundamental requirements simplicity and low maintenance, attention was directed t the motor design. A careful study was made based on th experience of more than 40 years with various types of a- multiple-unit car motors. The combination selected employs series fields and interpoles in the stator, no compe sating windings, and resistance leads in the armature t secure simplicity in both motor and control.

A resistance-lead motor has many desirable feature Because resistance leads carry current only when th corresponding commutator bars are under a brush, whic occurs in any one lead only about ten per cent of the tim the resistance of each lead can be made high enough limit substantially circulating current in the brush face an armature circuit at standstill and at low speeds. This r lieves local heating on the commutator surface and in th brushes.

Circulating currents in the brush face are the result voltage induced in the armature coils by the alternatin flux per pole. Because the circulating currents can be hel to safe values by the resistance leads, it was possible on th motor to increase the exciting flux per pole at start and lo speeds to almost twice that permissible on a motor with r resistance leads.

Increasing the flux per pole increases the line voltage an lowers the line current and number of poles accordingl The required starting tractive force is obtained with on eight poles at 1,050 amperes, as compared to 12 poles an 1,800 amperes necessary in an equivalent convention motor.

The low number of poles and comparatively low curre

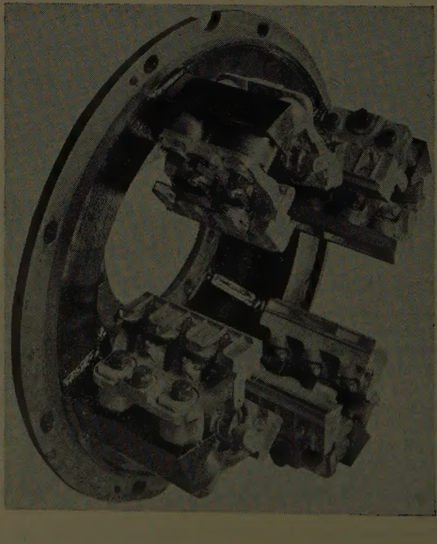
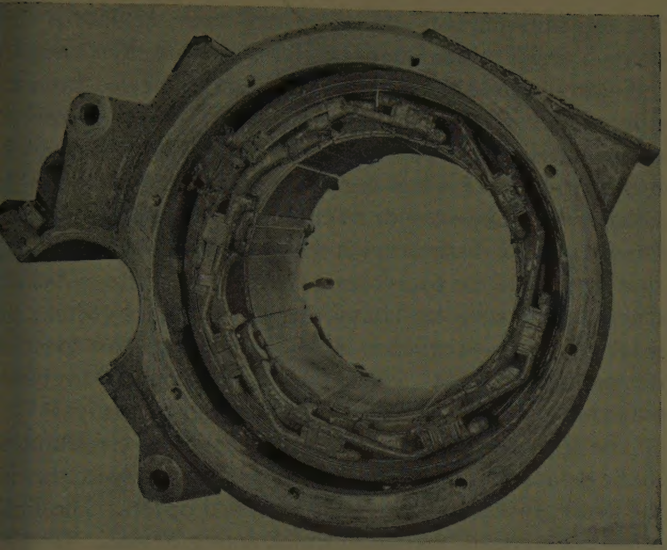


Figure 2. A ty 431-A motor—co mutator-end hou ing complete wi brushholder su ports and brus holders



igure 3. Wound stator of a type 431-A motor from pinion end

esult in fewer brushes, brushholders, and exciting and nterpole field coils.

In addition to the inherent advantages of a resistance ead design, various other improvements have been inorporated, some of which are shown in the figures. Figure is a view of the type-*431-A* assembled motor from the inion end showing the pinion, axle bearings, motor lead ables, and junction box. It is arranged for forced ventilaion and has a continuous rating of 225 horsepower at 328 olts. Each motor weighs 5,405 pounds complete with inion, gear case, axle bearing, and axle caps, which is ,220 pounds or approximately 20 per cent lighter than the notors previously used for the same service. The motors re geared to give the same accelerating tractive force per ar as the older motors but will operate at a sustained runing speed of 90 miles per hour as compared to 70 miles per our with existing equipment.

Many of the insulation failures on commutator motors re developed by introducing ventilating air at the comnutator end. On the *431-A* motor, ventilating air is introluced at the rear or pinion end, so that carbon dust from rush wear is blown out of the motor instead of into the vindings. This materially reduces the possibility of ccumulation of dirt on exposed creepage surfaces. It also as the advantage that if the commutator covers do not fit ightly or if they fall open or drop off, ventilation will not be ffected.

Figure 2 illustrates the commutator end housing. Comnutator motors usually have brushholders mounted in the rame, and any repairs, replacements, or neutral adjustnents tie up a complete motor. Here the commutator-nd housing, complete with brushholders, forms an assemly which is located on neutral by means of the half-hole the flange. This half-hole fits around a dowel pin set on eutral and welded in place on the frame flange. The ntire assembly may be removed for replacement and bench epair.

To improve the insulation of stator coils and to reduce oil-lead breakage, the exciting field coils are formed, prensulated, and baked before winding into open slots. The coils are connected, all in series, to carry full line current, and thus the conductors are of substantial cross section and strength. The interpole coils, like those on d-c motors, are completely wound, insulated, and baked before winding over the interpole. This makes the construction simple and rugged.

Wiring and connections of the exciting field coils are made at the rear or pinion end of the stator as in Figure 3. Completely preinsulated and baked, these coils are wound under the main pole tips by a new and novel method of first expanding the coils to pass over the pole tips and then stretching again to bring the coil sides in place against the main pole body. The interpoles have no tips and the sides are parallel. Hence, after the exciting field coils are in place, the interpole coils, preinsulated and baked, are dropped down over the poles in the usual manner.

Armature coil ends are connected to resistance leads at the rear end of the armature. The ventilating air, entering at the rear, blows down over these connectors and then under the coil support into axial holes through the armature punchings and out again at the front end between coils just ahead of the punchings. At the commutator end of the armature, Figure 4, the resistance leads pass from the bottom of the armature slots to the risers of the commutator bars, thus connecting the armature coil ends at the rear to the commutator bars at the front end of the armature. The outside cylindrical surface of the risers is insulated with glass and mica and serves as a supporting surface, upon which the armature coil ends are banded down in place. This allows the armature coils to expand and contract independent of the commutator risers. The commutator is of the disk spring-ring type designed for high-speed operation.

CONTROL EQUIPMENT

THE CONTROL equipment was designed with the same objectives of simplicity, reliability, and reduced maintenance. This has been accomplished without the introduction of radically new devices or systems. The simplicity of the main circuit is apparent from the schematic diagram, Figure 5.

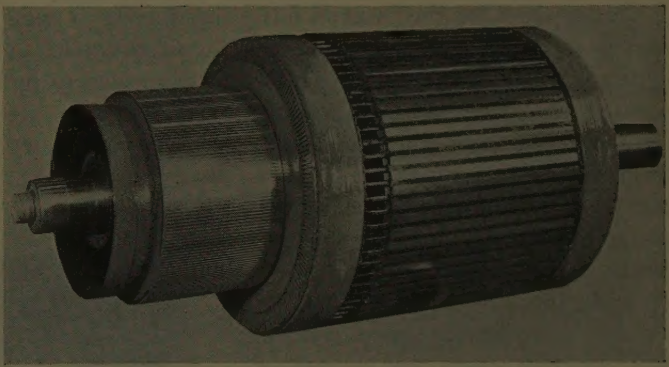
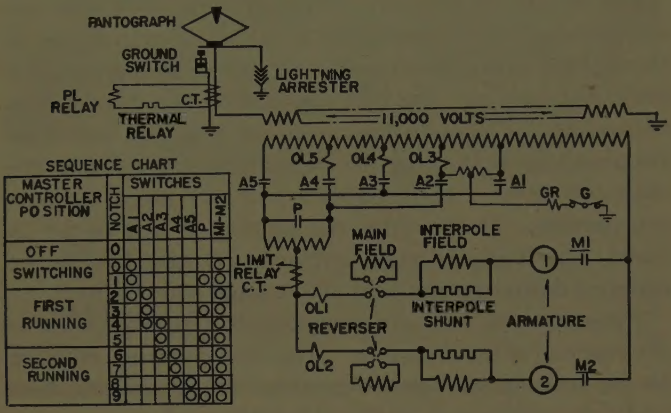


Figure 4. View of armature of a type 431-A motor from commutator end

The two traction motors are connected in parallel to minimize the amount of wheel slippage. With wet rail, it has been demonstrated on these cars that when one pair of wheels slips, the slippage is for only a small fraction of a revolution. On older multiple-unit cars, the two motors are connected in series. When one pair of wheels starts to slip, the voltage across the motor driving them increases, and the wheel slippage becomes progressively worse until power is finally removed by the slip relay. No slip relays are required on *MP54E5* cars.



SEQUENCE CHART

MASTER CONTROLLER POSITION	NOTCH	A1	A2	A3	A4	A5	P	M1-M2
OFF	0							
SWITCHING	0	○						○
	1	○					○	○
FIRST RUNNING	2	○	○					○
	3		○				○	○
	4		○	○				○
	5			○			○	○
SECOND RUNNING	6			○	○			○
	7				○		○	○
	8				○	○		○
	9					○	○	○

Figure 5. Main circuit schematic diagram of the MP54E5 multiple-unit car

These new cars possess another advantage. The failure of one motor on an old car necessitates cutting both motors out of circuit because they are connected in series. On the new cars, the motor in trouble is disconnected by opening switch *M1* or *M2*. Only half of the tractive power is lost. This means less overload for the remaining cars in the train.

A feature of these cars is that separate blowers are provided for ventilating each of the traction motors and the main transformer. The two traction-motor blowers are provided with cleaning devices to remove dirt and snow by centrifugal action, thus reducing failures from these sources. If the traction-motor ventilating-air pressure is too low, a diaphragm-type air relay opens the traction-motor switches.

The primary of the Askarel-filled transformer is connected to the pantograph by a high-tension cable. A lightning arrester, located on the roof, is connected to the pantograph. The six low-voltage secondary taps are located at one end of the transformer. They are protected from dirt and water by a metal housing. The six insulated copper straps connected to the taps are brought out of this housing through a block of insulation. Short flexible cables connect them to the main control box terminals which are located at one corner of the control box.

In addition to five tap switches, the main control box also contains two motor switches and one preventive coil switch. All eight of these electropneumatic switches are identical except for the interlocks. The interlocks are of the modern cam type. A Micarta cam attached to the movable portion of the switch bears against a ste contact finger which opens or closes the interlock contac

Figure 6 shows the main control box as viewed from th side of the car with covers removed. The 2-motor r verser, mounted at the right end of the control box, is th drum type. The straps emerging from the box above th reverser are connected to traction motor cables on the ca Directly below these straps is the shield for the six termina that connect to the transformer. At the opposite end of th box is a compartment containing the sequence switch, th limit relay, the sequence relay panel, and the groun detector relay panel. These devices are mounted in such way that they are inspected and maintained easily.

The sequence switch is a positive-notching electropne matic device that opens and closes the five tap switches ar the preventive coil switch in the desired order. The lim relay is a statically balanced quick-acting device. It is s to give the desired accelerating current. The setting is n affected by vibration or road shock.

Particular care has been taken to improve the protecti equipment. A ground-detector relay *GR* is connected ground through the "OUT" contacts of relay *G*, as show in Figure 5. If a ground occurs in any of the seconda circuits, *GR* operates. This closes *G*, which breaks t ground connection to *GR*. The intentional ground is th removed and *GR* opens. *G* holds itself closed and ligh ground-indicating lamps.

There is a thermostat in the transformer which actua an auxiliary relay, when the Askarel reaches too high temperature. This relay opens the motor switches. Ad tional protection is provided by the pantograph-loweri relay *PL* and a thermal relay. If an overload of lar magnitude occurs, the *PL* relay operates. This closes t pantograph ground switch. The resulting high troll current trips the substation circuit breaker and clears t line. When power is removed, the *PL* relay goes to t position that lowers the pantograph on the car that is trouble. The *PL* relay latches itself in this position. T operator cannot raise the pantograph. An overload bel the *PL* relay setting, but high enough to damage the ma transformer if it persists too long, causes the thermal relay operate. This closes the pantograph ground switch. T ground-switch current passes through the current tra former. Being a very-high-speed device, the *PL* rel

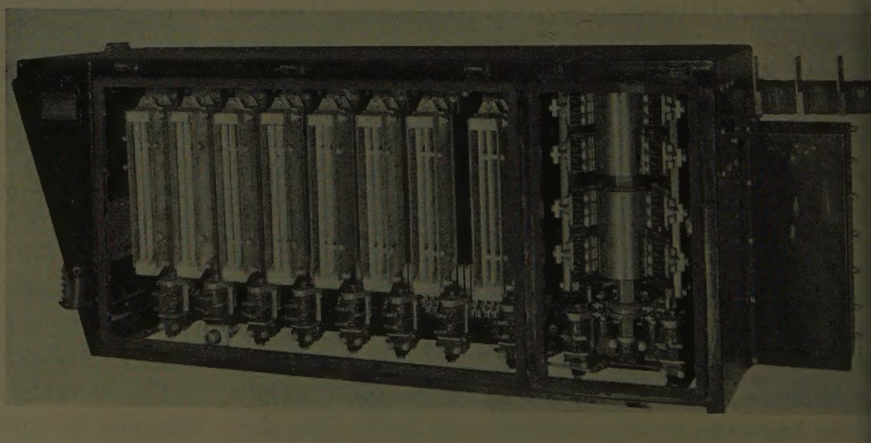


Figure 6. Front view of MP54E5 multiple-unit car main control box

operates before the substation circuit breaker clears the line. When power is removed, the pantograph is lowered by the *PL* relay. If a short circuit occurs across certain low-voltage sections, the resulting primary current will not be high enough to operate the thermal relay. This is the reason for overload relays *OL3*, *OL4*, and *OL5*. The closing of one of these relays operates the pantograph ground switch. The same sequence follows as described for the thermal relay.

The reliability of the 9-notch control scheme utilizing transformer tap switches has been demonstrated on the older class *MP54E3* cars. To this, the *MP54E5* cars add the great advantage of parallel motors and numerous protective features.

RECTIFIER-TYPE MOTIVE POWER

The industry continues to search for reduction in cost and increase in reliability. One of the most effective ways to reduce the first cost of multiple-unit car equipments is to employ standardization of systems and apparatus to a much greater degree than has been done in the past. There is a wide variation in equipment which has been selected for multiple-unit cars by various companies, both as to power-supply systems and also in the details of the traction apparatus. The effect of standardization in keeping costs low is well illustrated in the Diesel-electric locomotive field. In the period from 1939 to 1948, the price per pound of a 2,000-horsepower Diesel-electric road locomotive increased an average of only approximately 20 per cent as compared to an increase during the same period of approximately 150 per cent for a 4-8-4-type steam road locomotive. This relatively low increase for the Diesel-electric locomotive in a period of rising labor and material costs may be largely attributed to mass production of standardized units.

Suburban electrification in this country may be divided into three general systems as related to the power supply—11,000 volts, 25 cycles, alternating current; 600 volts, direct current; and 1,500 volts to 3,000 volts, direct current.

Each system has certain advantages. The high voltage of the a-c system makes it possible to supply economically large amounts of power over long distances.

The low-voltage d-c system includes the advantage of the d-c traction motor in higher efficiency, better starting tractive effort characteristics, and relatively low maintenance.

The high-voltage d-c system approaches the advantages of the a-c system in reducing transmission losses while retaining some of the advantages of the d-c traction motor.

It has been necessary until very recently to weigh the relative advantages of these systems and to select that which appeared to be the best compromise for the particular application, relinquishing the advantages of the others. Today, however, the excellent results which have been obtained with Ignitron rectifier-type motive power as applied for trial in 1949 to a Pennsylvania Railroad multiple-unit car give promise of a new system which embodies the advantages of high-voltage a-c transmission with the superior characteristics of low-voltage d-c motors.

The relative number of motor cars and trail cars in service on electrified main lines in each of the three power supply classes is indicated graphically in chart *A* of Figure 7. Of the total number of cars 63 per cent are operated at 600 volts d-c, 22 per cent at 11,000 volts a-c, and 15 per cent at 1,500 to 3,000 volts d-c.

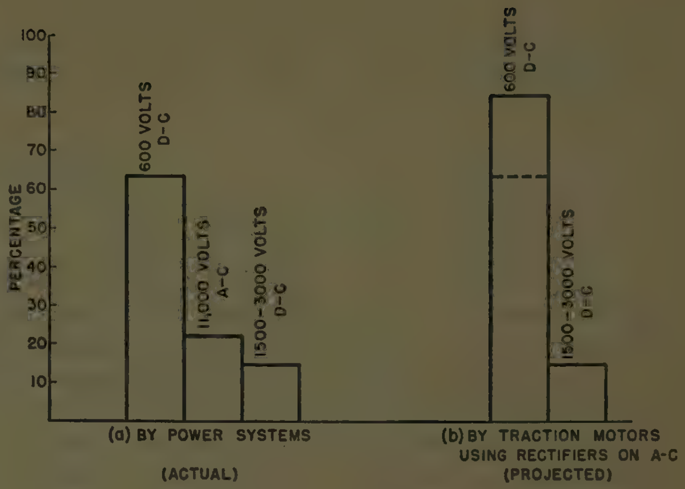


Figure 7. Distribution of multiple-unit cars in main line service in the United States

The wide use of low-voltage d-c motors and control is one of the factors which stimulated the development of Ignitron rectifier equipment for a-c electrifications. The basic requirement for this type of service using modern cars of 60 to 70 tons is approximately 400 horsepower per car. In this range, 600-volt d-c equipments, using either two or four motors, have been produced in considerable quantities. The essential elements of a rectifier-type a-c multiple-unit car equipment are a standard d-c package, including motors and control, and a conversion unit including transformer, Ignitron rectifier, and associated details.

Reference to chart *B*, Figure 7, illustrates how application of 600-volt d-c motors and control to existing a-c systems would increase the preponderance of low-voltage d-c equipment to 85 per cent of the total.

Thus, rectifier motive power not only has advantages over a-c single-phase motive power of lower weight, less space, higher efficiency, and higher power factor, but also advances the cause of standardization of multiple-unit car equipment. This is in addition to the possibility it affords of using commercial 60-cycle power for new electrifications, thus further applying the principle of standardization to reduce costs.

It is realized that this possibility for standardization depends upon proof of satisfactory long-range operation of rectifiers and associated equipment in motive power service. In January 1951, an a-c multiple-unit car equipped with Ignitron rectifiers and d-c motors had operated for a total of more than 35,000 revenue miles since the fall of 1949. During this period nothing occurred to raise any doubts as to its satisfactory life. Further evidence is accumulating as service continues. Other trial applications are in progress. Two 6,000-horsepower rectifier locomotives will be delivered to the Pennsylvania Railroad in June 1951. Also, the French, who are interested in 20,000-volt electrification at 50 cycles, have arranged to install an Ignitron equipment on a multiple-unit car for trial.

Chalk River N.R.X. Nuclear Reacto

D. G. HURST

The N.R.X. Nuclear Reactor at Chalk River, Ontario, has been operating for $3^1/_2$ years. Beside investigations on this experimental reactor itself, research is being conducted with the radiations. This may be divided into technological research for atomic-energy purposes and pure research in physics and radioactive chemistry.

AT THE Chalk River Laboratory, situated on the south bank of the Ottawa River about 125 miles northwest of Ottawa, Canada, a heavy water and uranium reactor has been operating for more than $3^1/_2$ years. The reactor building, shown in Figure 1, houses the reactor, see front cover, which consists largely of thick steel and concrete radiation shields, the concrete alone being eight feet thick. The reaction vessel is a cylinder about ten feet high by eight feet in diameter through which pass vertical tubes containing a total of 176 uranium rods.

The basic reaction underlying the operation is the fission of uranium by slow neutrons. When a neutron causes a uranium atom to undergo fission, a relatively large amount of energy is released and, at the same time, several neutrons are given off. To maintain the reaction, on the average one of these neutrons must cause a further fission, and the physical problems of reactor design are concerned with finding the most efficient way to achieve this condition. One method is to slow down the neutrons from their initial high speed and return them to the uranium as slow neutrons. The best substance available for this purpose is heavy water.

To start operation the heavy water is pumped from storage tanks into the reactor until a critical depth is exceeded. The power then builds up because over each neutron generation there is a slight increase in the number of neutrons. When the power reaches the required level, the depth of water is adjusted until the power stays constant. For ease in adjustment, a cadmium control rod is provided.

Figure 1. The reactor building, Chalk River Laboratory

The problems of normal operation have proved to be les than was expected in the earl days of the project. Th reactor runs very steadily usually under the control of a automatic pilot which by moving the control rod according to the current from a neutron-sensitive ion-chambe keeps the power within ±1/2 per cent of the chosen leve

To illustrate the behaviour of the reactor as a functio of time, a schematic analogue is presented in Figure where the number of neutrons, n, is represented by th input voltage. The neutrons have a lifetime T_1, and o capture their number is multiplied by the factor k. fraction p of the output nk is delayed by a time constan T_2 because it comes from delayed neutron emitters, fo simplicity represented here as being of a single group whos lifetime is T_2. Actually a number of delayed neutro groups occur but the general behaviour can be illustrate by using just one. S represents the background of neutron coming from all sources. The critical condition occur when $k = 1$ and represents a very delicate balance. Th delayed neutrons make the control problem relativel simple, for although p is only about 0.8 per cent and T about ten seconds, they make the response time quite lon for k close to unity. Since T_1 is only about one millisecond, the response of the reactor would be extremel rapid without the holdup due to the fraction p of delaye neutrons.

At high power there are other time-dependent effects Heating of the uranium and heavy water reduces k an helps to stabilize operation. Some of the fission product absorb neutrons so strongly that they affect the operatio by reducing k. To maintain the operation more heav water must be added to counteract the so-called "poisoning by these fission products. The amount of the absorbin product depends on the operational history, and in th analogue this has its effect on the amplifier gain in a complicated but reproducible way.

In terms of the Nyquist stability diagram for positiv feedback amplifiers, $k=1$ means that the $\mu\beta$ locus passe through the stability point. Greater k leads to instabilit less to stability. A simple analysis shows that for $k>$ the number of neutrons increases exponentially with

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Full text of a conference paper, "The Chalk River N.R.X. Nuclear Reactor in Oper tion," to be presented at the AIEE Summer General Meeting, Toronto, Ontari Canada, June 25–29, 1951. Recommended by the Committee on Nucleonics.

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The design, construction, and operation of the reactor has been the work of a numb of groups. The particular aspects discussed here owe much to the staff of the P Branch of the Industrial Operations Subdivision and to their willingness to arran conditions to suit the needs of experiment.

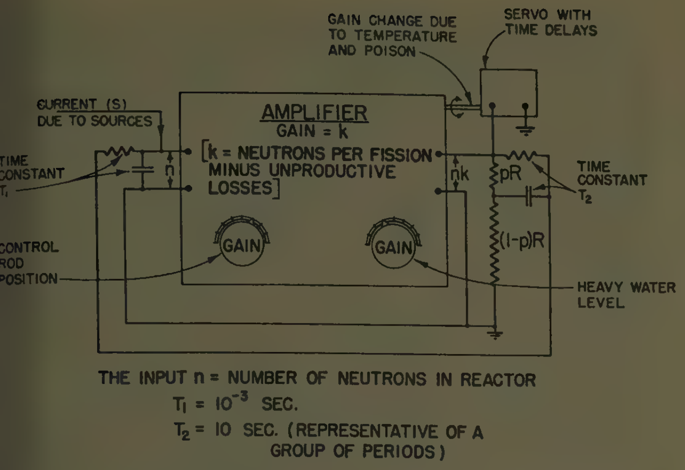

GAIN CHANGE DUE TO TEMPERATURE AND POISON
SERVO WITH TIME DELAYS
CURRENT (S) DUE TO SOURCES
AMPLIFIER
GAIN = k
[k = NEUTRONS PER FISSION MINUS UNPRODUCTIVE LOSSES]
TIME CONSTANT T₁
n
nk
pR
TIME CONSTANT T₂
(1-p)R
CONTROL ROD POSITION
GAIN
GAIN
HEAVY WATER LEVEL
THE INPUT n = NUMBER OF NEUTRONS IN REACTOR
T₁ = 10⁻³ SEC.
T₂ = 10 SEC. (REPRESENTATIVE OF A GROUP OF PERIODS)

Figure 2. A schematic analogue of a reactor. The time constants are supposed to be buffered or otherwise kept from loading other circuit elements. For simplicity, the many delayed neutron groups are represented by a single time constant T_2

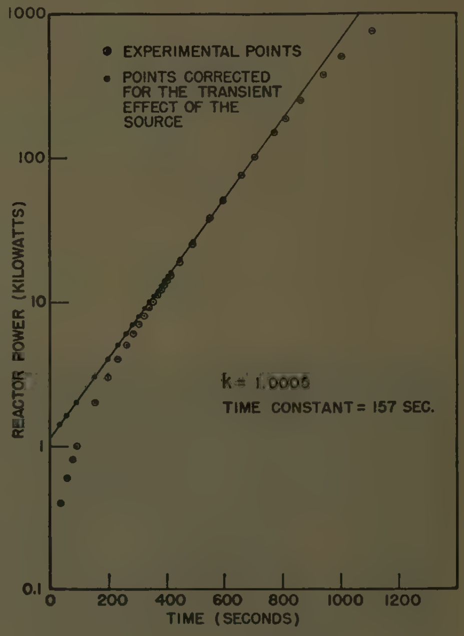
single time constant after transients due to *S* have become negligible, until at high power the heating of the uranium slows the rate of rise. A typical curve is shown in Figure 3. The initial transient arising from the effect of *S* has been corrected and the straight line corresponds to an exponential rate of increase over a large range of power. Hundreds of such curves were recorded for the measurement of *k*.

These measurements have been made because this is an experimental reactor. The word 'experimental' applies in more ways than one. The power of the reactor is in a very useful range. It is low enough so that an interruption of normal operation for experimental work does not cause the loss of an important amount of plutonium production. On the other hand, it is large enough to provide information on reactor technology under conditions unmatched anywhere for neutron flux. It is the compactness made possible by heavy water that gives the high flux combined with moderate over-all power. The design power was 10,000 kw, but this is exceeded in normal operation. The maximum flux is 6×10^{13} neutrons per second per square centimeter, which is about 12 times that in a graphite-moderated reactor of comparable power. These features, combined with an exceptional ease of control through variation of the heavy water depth, make the reactor exceedingly useful for experiments; for example, measurements made by letting the reactor "run away" to top powers approaching 20,000 kw with very accurate measurement of power as a function of time. Such a transient is shown in Figure 4.

Besides investigations on the reactor itself, it is a research reactor in the sense that research may be performed with the radiations. This may be divided into technological research for atomic-energy purposes, for instance, studying the effects of radiation on construction materials, and pure research in physics and radioactive chemistry. N.R.X. is also a production reactor in a restricted sense. First of all it produces plutonium in an amount determined by the power output and accordingly not in spectacular quantities. The most interesting of the products are the various radioactive isotopes which are prepared by neutron irradiation of materials, and here again the high flux makes possible commercial production of active material in unequalled concentrations. For example, cobalt 60, a radioactive isotope produced by neutron capture in ordinary cobalt, emits penetrating gamma rays and is consequently a substitute for radium in therapy and radiography. It is essential that the cobalt source be small in size to give well-defined beams and to minimize self-absorption; in other words the concentration of cobalt 60 must be as high as possible. The maximum concentration of an activity produced by neutron capture is proportional to the neutron flux, and for this reason N.R.X. is a pre-eminent producer of cobalt 60.

The production and decay of such radioactivities is analogous to the charging of a parallel resistance-capacitance circuit by a current proportional to the neutron flux and the discharging by the loss through the resistance. If the time constant of the circuit is equal to the mean

Figure 3. The growth of power for k > 1. The curvature at the higher powers is due to thermal effects



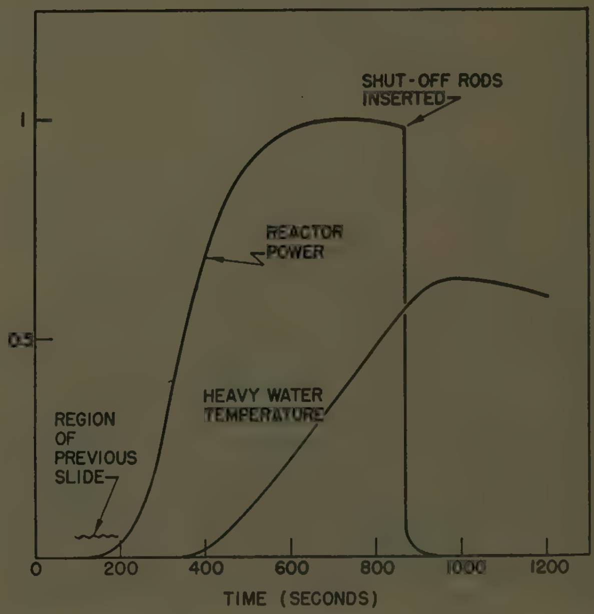


Figure 4. The growth of power until limited by thermal effects

radioactive lifetime, then the charge on the capacitor is proportional to the amount of active material present at any time. It will be seen why the larger the current (that is, flux), the greater the activity. It will be seen also that maximum activity is approached only after "charging" steadily for several time constants. In practice, cobalt irradiations of about six months' duration in N.R.X. yield satisfactory activities, although far less than the maximum obtainable. Sources equivalent to 1,000 grams of radium in gamma-ray intensity are prepared.

The arrangements for neutron irradiation are varied. Substances like cobalt, which require high flux, are irradiated inside the reacting core, and for isotopes of short life a pneumatic tube provides quick withdrawal of the material. Many isotopes can be produced in sufficient quantities by the neutrons which escape from the core. Figure 5 shows the mechanism for inserting such samples. At the other side of the reactor, Figure 6, research apparatus is arranged outside the shield for experiments with beams of neutrons released from the interior of the reactor. From the points of view of both the experimenter and the project, it is worth while to invest time and money in automatic control and recording devices so that the experiments continue day and night without interruption, except when the reactor is shut down.

As an example, the functioning of a neutron spectrometer (center foreground of Figure 6) is described in some detail. In this instrument neutrons of a single energy are selected from the neutron beam by diffraction at a crys of rocksalt in a manner very similar to the diffraction X rays. The scattering of these neutrons by the substan under investigation is measured as a function of the scatt ing angle. The neutron detector is a boron-trifluori proportional counter in which the signal due to a neutr is a pulse of about ten millivolts' magnitude and a f microseconds' duration. The pulses are amplified a fed to a decade scaler which records every ten, hundre and thousand pulses on separate channels of a 10-p strip-chart chronograph. The detector is carried on arm pivoted about the specimen and driven at a consta angular rate, going to and fro between limit switch which can be adjusted to include any range of angl The direction of the arm's motion is marked on the cha and to check the details of the motion a phonograph pick records on the chart the passage of each division of a gra uated circle. A monitor counter records on the same cha the intensity of the incident beam. When the reactor shut down or is not on automatic control, the spectromet does not operate and counts do not accumulate in t scalers; the instrument halts until automatic control re-established, and this also is recorded on the chart.

An alternative drive is preferred for some types scattering. The arm has predetermined angular positio and moves from one to the next after a set number neutrons has been counted. In this case the time spe at each position is recorded.

It will be appreciated that reliability of electronic equi ment is of prime importance in apparatus of this kind. Chalk River considerable effort has been put into t design of reliable scalers and amplifiers. Maintenan records show that the instruments of recent design have failure rate, for all types of failures, of one per year eight tubes in the system.

Many physics experiments have been performed, usi neutrons from the reactor. Among them are a study the radioactive decay of the neutron, a re-evaluation of t neutron mass, and the measurement of the energies a intensities of gamma rays emitted on neutron capture.

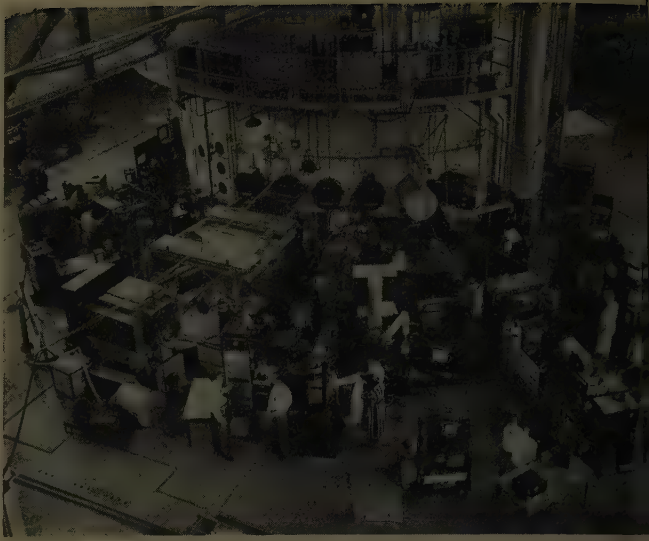


Figure 6. The experimental face of the reactor

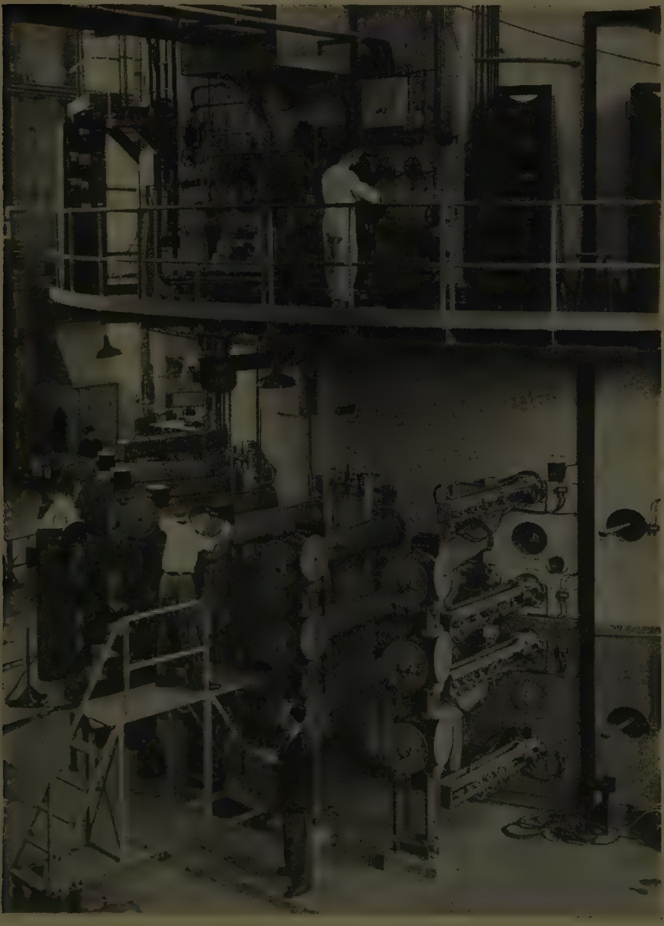


Figure 5. Mechanisms for inserting small samples for activation

Equivalent Circuits of Shaded Pole Motors

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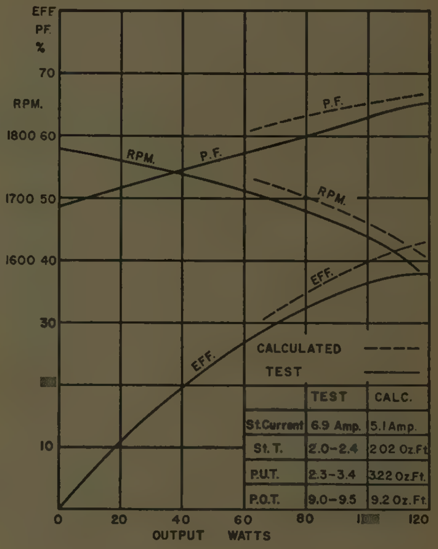
AS A RESULT of study and experimental work, a present-day shaded pole motor with good accelerating characteristics and 35- to 40-per cent efficiency is not uncommon. With improved efficiency, the horsepower ratings of these motors are also extended from the subfractional to the fractional range. Experimental results leading to this improvement can be co-ordinated and integrated into infallible rules for designing shaded pole motors with the aid of the equivalent circuit.

Theoretically, the essential difference between an ordinary induction motor and a shaded pole motor lies in the latter's abundance of space harmonics, due to concentrated windings. Though the air gap harmonic flux in other salient pole machinery can be reduced by properly shaping the pole face, such a measure cannot be used in shaded pole motors without impeding the cross field flux and increasing excessively the magnetizing current. Both theory and experience indicate that an adequate magnetic path must be provided in the stator all along the rotor surface. The magnetic path in between poles can either take the form of a magnetic bridge or an extended pole tip.

The harmonic flux causes cusps in the speed torque curve, increases rotor loss, and reduces the useful torque of a shaded pole motor. Yet in much authentic work on machinery analysis the harmonic flux is regarded as nothing but another form of leakage reactance. What factors make it so harmless in ordinary motors but so harmful in a shaded pole motor?

Take as an example the third harmonic flux in a 4-pole motor. It has the same frequency as the line frequency but is distributed in 12 poles along the air gap. It reacts with the squirrel cage rotor in exactly the same manner as a stator with 12 poles. Its effect is the same as a 12-pole motor on the same shaft of the 4-pole motor. Since both the magnetomotive forces are proportional to the line current and both the flux systems induce a counter electromotive force in the actual winding, the two fictitious motors have their primary windings in series. The flux in the 12-pole motor revolves at 600 rpm. It lags behind the rotor and acts as a brake when the shaft speed is above 600 rpm. The braking action reaches its maximum when the speed is slightly above 600 rpm and a cusp is introduced in the speed torque curve.

Rotor skew is the most important measure to reduce the effects of space harmonics. With skew, the rotor and stator currents do not act on the same magnetic path. The mutual reactance is reduced, and both the stator and rotor leakage reactances are increased in equal amounts. By shifting the total reactance from the mutual reactance to leakage reactance, skewing reduces the induced currents in the rotor. Since the amount of skew is measured in electrical degrees, it effectively reduces the harmonic rotor currents with only a slight reduction in the fundamental rotor current. In an induction motor with distributed winding, there are only a few important harmonics which can be decoupled almost completely from the rotor circuit by a proper amount of skew. In a shaded pole motor, all orders of space harmonics exist and only partial reduction of the rotor harmonic currents can be obtained from a single value of rotor skew. The best compromise is at about 60 electrical degrees of the fundamental flux.



	TEST	CALC.
St.Current	6.9 Amp.	5.1 Amp.
St. T.	2.0–2.4	2 02 Oz.Ft.
P.U.T.	2.3–3.4	3.22 Oz.Ft.
P.O.T.	9.0–9.5	9.2 Oz.Ft.

Figure 1. The calculated and test performance of a 1/10-horsepower 4-pole shaded pole motor

Another important consideration in designing a shaded pole motor is the difference in phase angle between the line current and the shading coil current. The starting torque depends on this angle and the maximum torque, efficiency, and quietness in running increase as the angle is increased. By properly choosing the shading coil pitch, the harmonic and skew leakage reactances can be shifted from the unshaded pole to the shaded pole to increase the phase difference between the two currents. This criterion determines that proper range of shading coil pitch be from 46.5 to 60 electrical degrees.

Besides the skew and shading coil pitch, recommendations are made relating to other pertinent factors which include: size and position of the shading coil, magnetic bridge, number of rotor bars per pole, and the rotor conductor and end ring resistance.

The performance of a 4-pole 60-cycle $^1/_{10}$-horsepower shaded pole motor is calculated according to the equivalent circuit. A comparison between the calculated and test values is given in Figure 1.

Digest of paper 51-116, "Equivalent Circuits, and Their Application in Designing Shaded Pole Motors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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A New 69-Kv Air Blast Circuit Breaker

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AIR BLAST circuit breakers were selected recently for a metropolitan station requiring circuit breakers rated 69 kv, 2,000 amperes and capable of interrupting 3,500 megavolt amperes within five cycles. This installation forms part of an outdoor metal-enclosed switchgear equipment and a metal-enclosed circuit-breaker design was desired.

Performance of an air blast interrupter depends on both voltage recovery rate and short-circuit current, but the new circuit breaker has been designed to handle any recovery rate which may be encountered in this country to permit its application on a fault current basis only. From reports of recovery rates on several utility systems and an analysis of system connections conceived possible in metropolitan areas, 6,000 volts per microsecond was determined as the maximum natural recovery rate whi would be encountered at 69-kv 3,500-megavolt-amp duty. A double-interrupter style of circuit breaker w developed to provide one interrupter for inserting a r sistor limiting recovery rate on the fault interrupti contacts; a second interrupter is used to break the resist current prior to opening of an isolator.

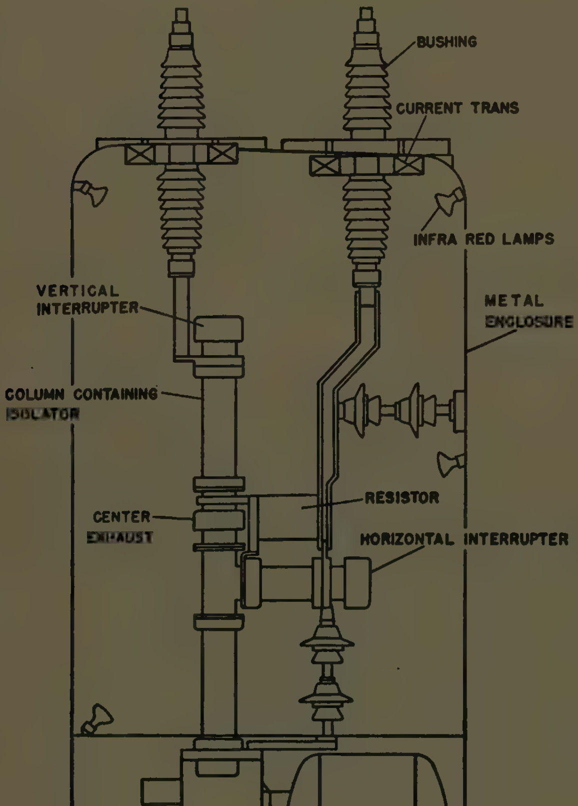

Figure 1. Sectional view of new 69-kv 2,000-ampere 3,500-megavolt-ampere air blast circuit breaker in outdoor, dust-tight metal enclosure of phase-isolated construction. A metal barrier is provided between the primary and mechanism compartments

Although metal-enclosed 69-kv circuit breakers may desirable at other locations, 69-kv circuit breakers have be more commonly applied as porcelain-clad outdoor uni However, for outdoor service air blast circuit breake would have more reliable operation under icing conditio if the open-type isolating switches usually associated wi high-voltage air blast designs were changed to enclos isolators. Therefore, an isolator has been designed with the air column as a functional part of the resistor curre interrupter.

The phase-isolated equipment at the first installation the new circuit breaker provides a complete metallic hou ing for each phase conductor with an air space betwe individual phase housings. Although the circuit-break enclosure is arranged to permit normal inspection ar maintenance is readily accomplished without removing ar enclosure covers, it would be advantageous to be able readily remove a circuit-breaker pole for interchange wi a spare element or for maintenance at a more convenie point. The new circuit-breaker design therefore consis of three single-pole, roll-out type units with each pole in a individual dust-tight metal enclosure (see Figure 1).

An outdoor installation of the new circuit breaker witho a metal enclosure will consist of the addition of porcela around the vertical and horizontal insulating tubes, plus metal housing for the mechanism only.

Selection of air blast circuit breakers frequently has be based on the elimination of the hazard of oil fires, but t elimination of oil can result in an interrupter design whi permits simpler and faster inspection. This inherent a vantage of air blast circuit breakers has been extended the new design by hinging the interrupter units to perm their being readily swung open for contact inspectio Inspection of wiping contacts on the isolator is performed simple unbolting of a retainer housing.

The new features of this 69-kv air blast circuit break insure ease of inspection and maintenance and decrea outage time. Furthermore, test performance has indicat that the design can be extended to 5,000 megavolt ampe when such an increase is required. The enclosed isolat is a feature which should result in ready acceptance of t circuit breaker as an outdoor porcelain-clad unit.

Digest of paper 51-27, "A New 69-Kv Air Blast Circuit Breaker," recommended by AIEE Committee on Switchgear and approved by the AIEE Technical Prog Committee for presentation at the AIEE Winter General Meeting, New York, N. January 22-26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1

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Radio Influence Tests in Field and Laboratory—500-Kv Test Project

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A study of radio influence has been made on 500-kv test lines. The effects of weathering, precipitation, variations in voltage, frequency, and conductor diameter were all investigated.

MEASUREMENTS of radio influence, designated as R. I. in this article, have been made near the high-voltage-line conductors at the 500-kv test roject of the American Gas and Electric Comany[1–7, 11, 12] to obtain data for use in the design of high-oltage lines. The test site includes one 3-phase line 800 eet long and two 3-phase lines 1.36 miles long, all on steel owers with ground wires on he two longer lines. To upplement this work tests vere also made at Trafford Laboratory of the Westingouse Electric Corporation nd on operating 138- and 30-kv lines. It is believed that the data obtained as vell as the instrumentation and test methods used will be seful in predicting radio-influence characteristics of lines.

As test work progressed, it was necessary to change plans nd procedures because the radio influence was affected y many unforeseen weather as well as circuit variables. Even progress during the last three years on instruments for neasuring radio noise required repetition of some tests nd revision of others.

INSTRUMENTATION AND MEASUREMENT

THE MEASUREMENT of radio noise with instruments constructed according to radio noise meter specifications[8,9,10] s necessary throughout a test program which is intended o give results applicable in the future. The latest speciications[9] for instruments require that meters read three haracteristics of the noise: average, quasipeak (weighted letector circuit), and the peak values after transmission hrough specified bandwidth circuits.

DISCUSSION OF TEST RESULTS

Effects of Weather. Rain will increase R. I. by several imes for conductors of the size used for power transmission. Tests were made in fair weather and in rain on the same day r on consecutive days. These tests showed R.-I. increases lue to rain from 4 to 25 times for quasipeak and peak values nd three to six times for average values. Visual data nd analysis of graphic records with results as shown in Figure 3 gave average increase of quasipeak values of four times for Tidd conductors and an increase of four times for 138-kv lines in service. R. I. does not decrease immediately as rain ceases, rather it has no perceptible change immediately but after a short time, depending on the voltage, begins to decrease gradually at a rate also depending on the voltage.

Fog may or may not produce a large increase in R.-I. value over the fair-weather value. An increase will be obtained if sufficient condensation occurs to wet the conductor. Snow on the conductor increases R. I. but to a lesser extent than water. In one test with snow melting on the conductor R. I. was 3.5 times greater than before the snow began to melt.

If the R.-I. value for rain is established it may be used as indicating the maximum which will exist, excluding conditions such as hoar frost and ice, for which no data were obtained.

Weathered Conductors. Weathering can reduce R. I. at the higher voltages when the conductor is dry. However, the threshold voltage may be lower than for a new conductor and the test values from day to day are not as consistent as for a new conductor. In fact, the smoother and cleaner a conductor is the more consistent the test results. With rain there is no significant difference between weathered and new conductors. It can be stated, therefore, that weathering of conductors will not result in any material increase in R. I. and can result in some reduction. What the amount of reduction will be depends on the condition of the conductor surface after installation.

Effect of Conductor Voltage. As the voltage on a conductor is increased the R.-I. threshold voltage can be detected readily on new and dry conductors in the laboratory by radio noise meter headphones. On dry weathered conductors and on all conductors in rain the threshold voltage is not as clearly defined by listening. R. I. occurs first on the negative half-cycle on new dry conductors, and for usual operating voltages exists only on the negative half-cycle. With weathered conductors at usual operating voltages, R. I. exists on both half-cycles, as can be seen by laboratory oscillogram Figure 4*C*. For wet conductors R. I. is generated chiefly on the positive half-cycles for both the smooth and weathered conductors, as can be seen from oscillograms in Figure 4 obtained in the laboratory.

With increase in conductor voltage beyond the threshold voltage, R. I. increases rapidly as shown by the Tidd curves

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ssential text of paper 51-40, "Radio Influence Tests in Field and Laboratory—500-Kv Test Project of the American Gas and Electric Company," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Techical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transtions*, volume 70, 1951.

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of Figure 1 and laboratory curves, Figure 5. It will be noted that the rate of increase of R. I. differs for smooth and weathered dry conductors, Figure 5; whereas in rain it is about the same for both. The average, quasipeak, and peak values of R. I. increase with voltage at approximately the same rate as shown by Figure 1.

From the data obtained in the laboratory for the threshold voltage, the points near the calculated curves 8 and 9 of Figure 6 were obtained. The calculated threshold curve for stranded conductors is based on the relation

$$V_g = 21.1 \frac{(1+0.3)}{\sqrt{\delta r}} m\delta r \log_e \frac{S}{r} \text{ kilovolts to ground} \qquad (1)$$

where 21.1 is the critical gradient for air in rms kilovolts per centimeter; δ is the air density factor; r is the radius of conductor in centimeters; S is the spacing in centimeters (in this case $S=2h$ where h is height of conductor above ground plane used for laboratory tests), and m, the surface factor, equals 0.846.

Effect of Conductor Diameter on R. I. The effect of conductor diameter, as far as the starting voltage is concerned, is as given in equation 1 and is substantiated by the laboratory test data, see Figure 6. The voltage for a constant R.-I. value for smooth dry conductors can be obtained by adjustment of the gradient constant in equation 1. Similar relations of voltage to diameter apply with rain. It is, of course, necessary to use for rain a surface factor of 0.24 in conjunction with adjustment of the gradient constant. The constants for rain will give results agreeing within 10 per cent of test values for conductor diameters between 0.25 inch and 1.65 inches. Very fine wires, such as 0.040-inch diameter, will have values with rain less than when dry, and the effect of water on conductors above 1.65 inch decreases at least up to 2-inch diameter.

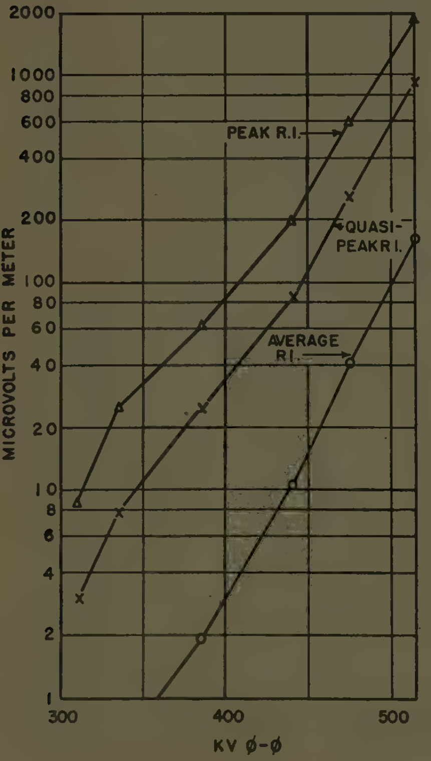


Figure 1. Typical voltage run at Tidd; 3-phase line, 2.0-inch diameter conductor. Average, quasipeak, and peak values of R. I. at 1.0 megacycle

By the use of laboratory threshold and 2,000-microv values and Tidd and existing line data, curves of conduc diameter to voltage phase-to-phase for 32-foot spaci were obtained and are shown on Figure 6. It can be se that the R.-I. threshold test points agree quite well w the calculated values. The laboratory threshold curve with rain was drawn from the test values. The fa weather curve for Tidd conductors, curve 4, for fi intensity of 15 microvolts per meter at 100 feet is for strand conductors. For Hedernheim (*HH*) copper conduct the corresponding curve 6 is slightly to the right; howev for rain the stranded and *HH* conductor data fall on t same curve, curve 3. Curve 15, for 150 microvolts p meter at 100 feet, is shown in order to indicate what increa in voltages would be obtained if the field intensity we increased ten times. Limited laboratory data on new a weathered stranded dry conductors for the 2,000-microv level are given in curves 10 and 11. These curves indica that the R.-I. level is lower for weathered than for new c conductors. Some of the data obtained on existing 138-

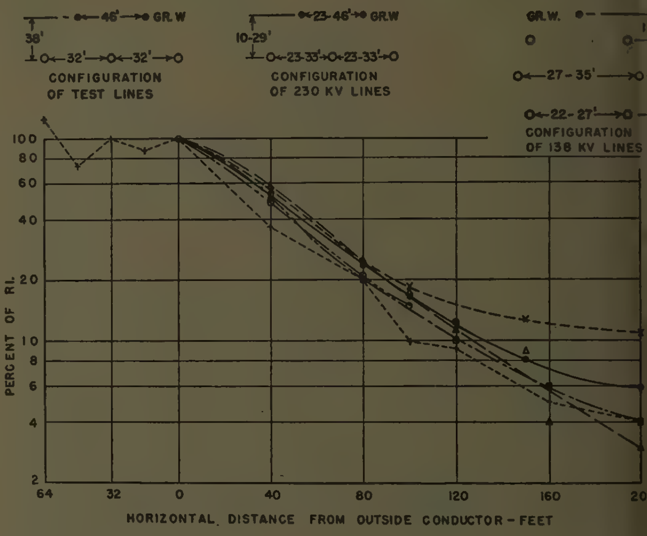


Figure 2. Attenuation of R. I. field intensity with distance fr transmission line

○ *Average of 28 tests—138-kv lines*
× *Average of 22 tests—230-kv lines*
△ *Average of 42 tests—Tidd lines; 280 to 450 kv*
● *Average of above 92 tests*
☐ *Calculated attenuation*
+ *Typical test at 395 kv*
All tests: quasipeak R.I., 0.2 to 1.5 megacycles, all weather—fair, rain, snow, and fog

and 230-kv lines are shown on curves 5 and 16. T points for these lines were obtained from field measu ments extrapolated to 15 microvolts per meter accordi to the R.-I.-to-voltage curves at Tidd. The operating l data fall fairly well on a curve extended from the Ti curve 4.

Effect of Lateral Distance. As the distance from the l increases, the R.-I. field intensity decreases rapidly, shown by Figure 2, which indicates the average values

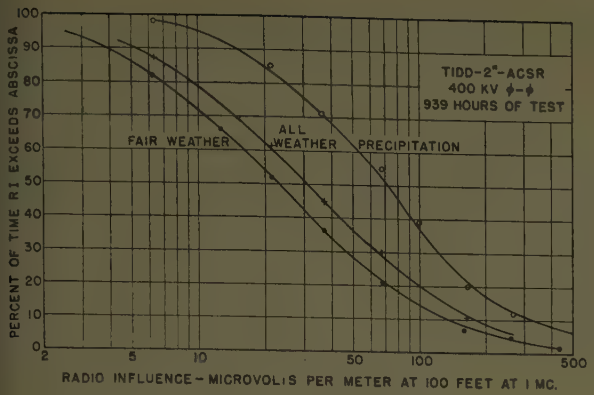


Figure 3. R. I. analysis from test-line chart records

several lines as well as the Tidd line. The dashed curve s calculated from the equation

$$P=\frac{100}{1+\left(\frac{D}{H}\right)^2}$$

where P is percentage at lateral distance from a point directly under the outside phase conductor and H is the conductor height at Tidd at mid-span.

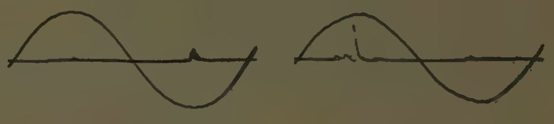
R.-I. Variation with Frequency. The value of R.-I. field intensity over the portion of the frequency spectrum of significance, as far as high-voltage line conductors are concerned, was obtained on successive days and constant weather conditions on Tidd test line number 2, and on a 138-kv 3-phase line. Figure 7 is for a 138-kv line in service with spacing as shown and for other lines as indicated. The data indicate that R. I. decreases quite rapidly as the frequency increases, and for line operating voltages at which reception in the broadcast band would be satisfactory, conductor R. I. may be ignored above 50 megacycles even for wide-band communication such as television.

Single-Phase and 3-Phase Tests. Single-phase and 3-phase voltage runs were made on the same day to obtain the correlation between R. I. for these two conditions. This was necessary because of the number of single-phase comparison tests made at Tidd. Typical fair-weather voltage runs single-phase and 3-phase are shown in Figure 3. At a voltage which might be used for the conductor tested the 3-phase to single-phase ratios are: 3.5 for average meter reading, 2.4 for quasipeak, and 2.3 for peak.

CORRELATION OF TIDD AND LABORATORY DATA

FROM Figure 6 we can see that laboratory data taken on dry conductors will indicate a conductor for R. I. which would be only one-third the diameter required. In fact, the dry threshold voltage in the laboratory is higher than the voltage at which considerable R. I. occurs on the Tidd lines. For rain conditions, however, the laboratory data correlate quite well with field results. The results from laboratory and Tidd data for dry conditions indicate the large effects of variations in the surface of weathered conductors. It was determined by oscilloscope studies, see Figure 4, that corona can exist on the positive half-cycle on dry weathered conductors, whereas on new conductors no corona appears on the positive half-cycle. It was also determined that during rain R. I. appears mostly on the positive half-cycle. These results show that a dry weathered conductor is similar in some respects in R.-I. characteristics to a conductor in rain or with water drops adhering to the surface. In the laboratory, where the test conductor was only 20 feet in length, one sample may not necessarily correlate with field data where much longer weathered conductors were tested. It was found on the test line that there were variations in fair-weather data as shown by Figure 3. If many samples of weathered conductors had been tested in the laboratory similar variations and better correlation with field data also might have been obtained. In any case it appears that a test in the laboratory on a smooth dry conductor is necessary to establish that the test setup used will follow equation 1. Then tests on any conductor dry and with rain will establish its R.-I. relationship to a smooth conductor or any conductor for which field and laboratory data are available.

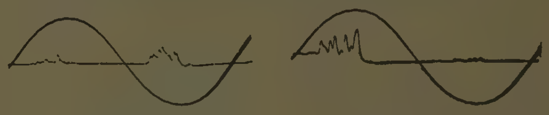
Operating Line Data. It was determined that the R.-I. level of lines of the 138-kv and 230-kv class have values quite consistent with other data presented in Figure 6. Experience also indicates that these lines are not the cause



(A) DRY AT 178 KV. WEATHERED CONDUCTOR

(B) RAIN AT 65 KV NEW CONDUCTOR

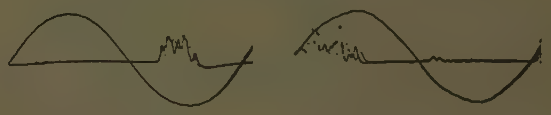
RI. START ON 556,500 CM. ACSR



(C) DRY AT 228 KV.

(D) RAIN AT 166 KV

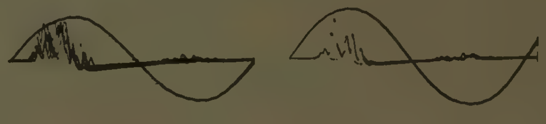
RI. ON WEATHERED 556,500 CM. ACSR



(E) DRY AT 228 KV.

(F) RAIN AT 166 KV.

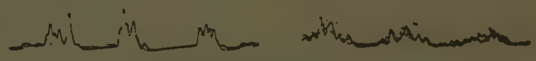
RI. ON NEW 556,500 CM. ACSR



(G) 1.65 H-H

(H) 2.0" ACSR

COMPARISON OF WEATHERED CONDUCTORS IN RAIN AT 177 KV.



(I) 2.0" ACSR TIDD LINE AT 400KV.

(J) 0.5" STRANDED COPPER WINDSOR-CANTON 138 KV

RADIATED RI. 40 FEET FROM 3ϕ LINE-FAIR WEATHER

Figure 4. Oscillograms showing R. I. from conductor radio noise under various conditions: A to H from laboratory tests, I and J from operating line tests

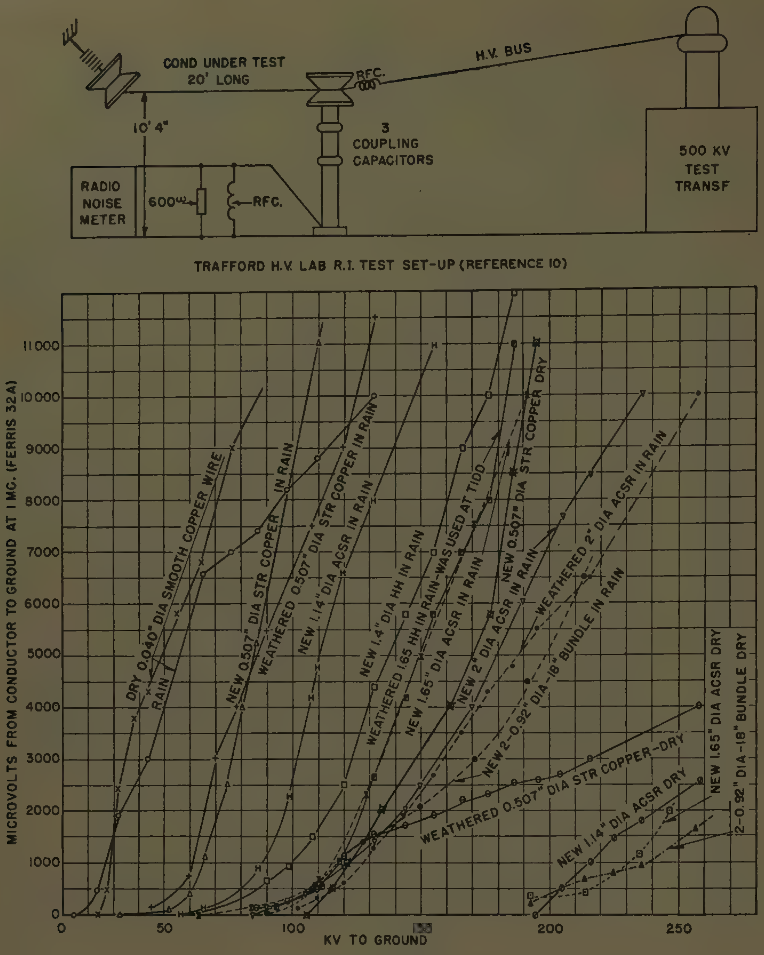


Figure 5. R. I. variation with voltage for conductors tested in the laboratory

of radio noise complaints for amplitude-modulated or television services and frequency runs made on these lines show that R. I. falls off rapidly with frequency; see Figure 7. Chart data from operating lines are similar to those obtained at Tidd. The difference between fair weather and rain is well established for this type of line and checks with data of Figure 3. It is indicated by the field data that the R.-I. effects for 138-kv double-circuit and single-circuit lines at distances 40 feet or more away from the line are about the same. It might be expected that the R. I. from a 2-circuit line would be equal to a single-circuit line times $\sqrt{2}$ if all conductors had the same R. I. However, because of the shielding effects of other conductors the over-all effect is about the same as for a single-circuit line. Vertical 3-conductor configuration gave results about the same as for three conductors in horizontal configuration.

Bundle Conductors. Some tests were made at Tidd and in the laboratory on bundle conductors. R.-I. threshold and other values for bundles are given in Figure 6, curves 12, 13, 14, 17, 18, and 19. In the case of 2-, 3-, and 4-conductor bundles tested (see Figure 9), the R.-I. threshold for a 2-conductor bundle was within five per cent of the calculated value at the optimum spacing $S/d=10$ and less than this at greater spacing. The small amount of data obtained at Tidd on a 2-conductor bun
consisting of 0.92-inch diameter stranded c
per conductors 20 inches apart was used
obtain the 15-microvolt-per-meter level at t
feet from the line shown in curve 7, Figure
From these data we see that the bundle c
ductor tested is equivalent in R. I. in
weather to a single 1.53-inch-diameter st
reinforced aluminum-cable conductor and
a 1.38-inch-diameter *HH* conductor. Fr
laboratory rain tests it is indicated that
2-conductor bundle is equivalent to a
inch-diameter steel-reinforced aluminum-ca
single conductor.

Present R.-I. Situation on Operating Lines. T
presentation includes, principally, test proc
ures and test data. It is also necessary to ev
uate the results in terms of the effect of R
on communication services.

The transmission lines of the American
and Electric Company system in the gene
voltage range of 69 kv to 138 kv have caus
very little interference to radio reception
der all weather conditions. The few cases
complaints that were definitely traced to
transmission system were found to be caused
defective insulators, and in some cases defect
line hardware and replacement eliminat
the interference.

With the increase in areas served by te
vision broadcasting, complaints from te
vision owners are increasing. These complai
are all investigated and almost without
ception the cause of interference is traced
causes other than radio influence from transmission lin

With the record of many years' experience in the
dustry with existing transmission lines in the gene
voltage range of 69 kv to 230 kv and the relative freed
from radio interference in the vicinity of these lines, i
believed that the magnitude of radio influence genera
by these lines is not sufficient to cause interference
amplitude-modulated radio or television, and that
existing R.-I. levels can be considered as conservativ
low for the design of new lines (see curve 5, Figure 6).

Tolerable R.-I. Level for Super-High-Voltage Lines.
effect of R. I. from high-voltage lines on communicat
services depends on factors such as:

1. Characteristics of R. I. due to corona.
2. Effects of this type of R. I. on communicat services.
3. Communication signal intensities along line.
4. Signal-to-noise ratios tolerable to communicat services which may be affected.
5. Distance of receivers from line.
6. Number of receivers per unit length of line.
7. Transfer of R. I. to lower voltage circuits.
8. Effects of weather.

This article will not attempt to make any evaluation olerable limit based on these factors. However, a reasonble approach can be made by the application of data resented in this article and field experience with radio nterference.

From Figure 6 it can be seen that curve 4 (Tidd tests) nd curve 5 (tests on operating 138- and 230-kv lines) all very nearly along the same curve. This indicates hat a proposed line using conductors based on curve 4 vould be expected to have an R.-I. level approximately he same as on the operating line, curve 5, and very little, f any, interference would be expected from conductors in he radio spectrum from 0.015 to 400 megacycles. Alhough no measurements were made bove 400 megacycles the frequency urves at 400 kv indicate that above 00 megacycles conductor R. I. vould be negligible.

The data of Figure 6 are believed o be conservative in predicting the R.-I. effects for super-high-voltage ines. The principal reasons for this re:

1. Lines travel across country nstead of paralleling roads and ow-voltage-distribution and other ines.

2. Fewer homes will be near hese high-voltage lines.

3. The antenna coupling to lines s lower than for low-voltage lines ecause of greater conductor height nd because of greater distances, n the average, from line to reeiver antenna.

CONCLUSIONS

1. Instrumentation methods used vere satisfactory, and for the tests lescribed gave very little trouble. nstruments for recording usually perated for periods of two weeks vithout any attention.

2. Tests on lines should include hart recording of R. I. and weather lata as well as spot checks.

3. New conductors when dry ave R. I. only during the negative alf-cycle at practical operating oltages.

4. Weathered copper or aluminum conductors when dry have R. . during both positive and negative alf-cycles.

5. New or weathered conductors, n rain or when wet, have R. I. nostly in the positive half-cycle.

6. The R.-I. threshold voltage or dry single or bundle conductors, s measured at 600-foot altitude, hecks the calculated corona threshold voltage. The correction (for air density factor) as used in equation 1 may or may not be accurate for R.-I. threshold for lines at high altitudes.

7. The threshold voltage with rain on smooth or stranded conductors occurs at 24 per cent of the threshold voltage for a dry smooth conductor.

8. Under rain or wet conditions R. I. will increase, except for fine wires, by several times.

9. Under rain or wet conditions smooth and stranded conductors of the same diameter have the same R. I.

10. A wet conductor, either with a fine droplet surface or with larger water drops, will have the same R. I. as

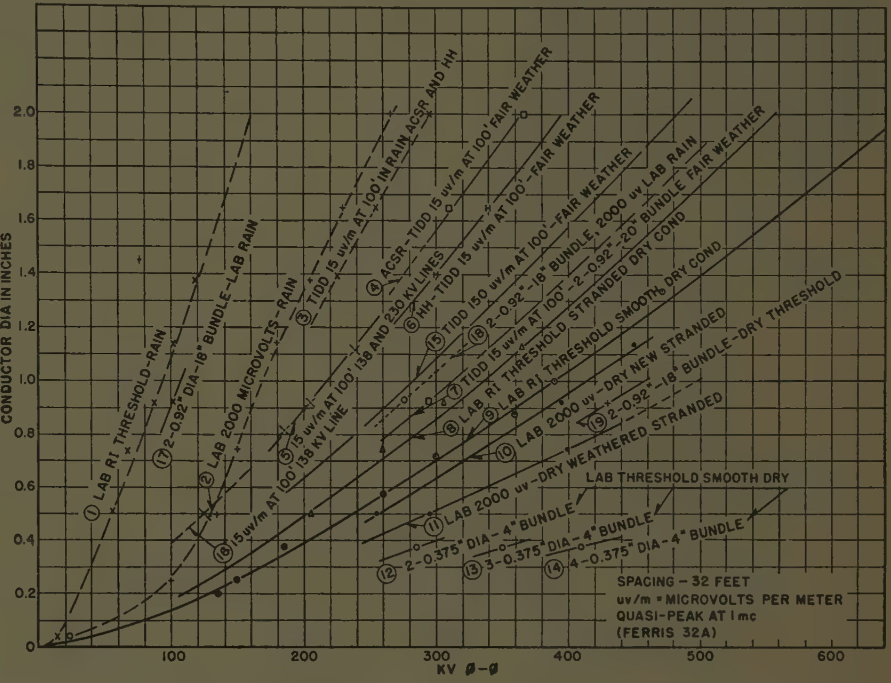


Figure 6. Conductor diameter and phase-to-phase voltage relations from laboratory and field data

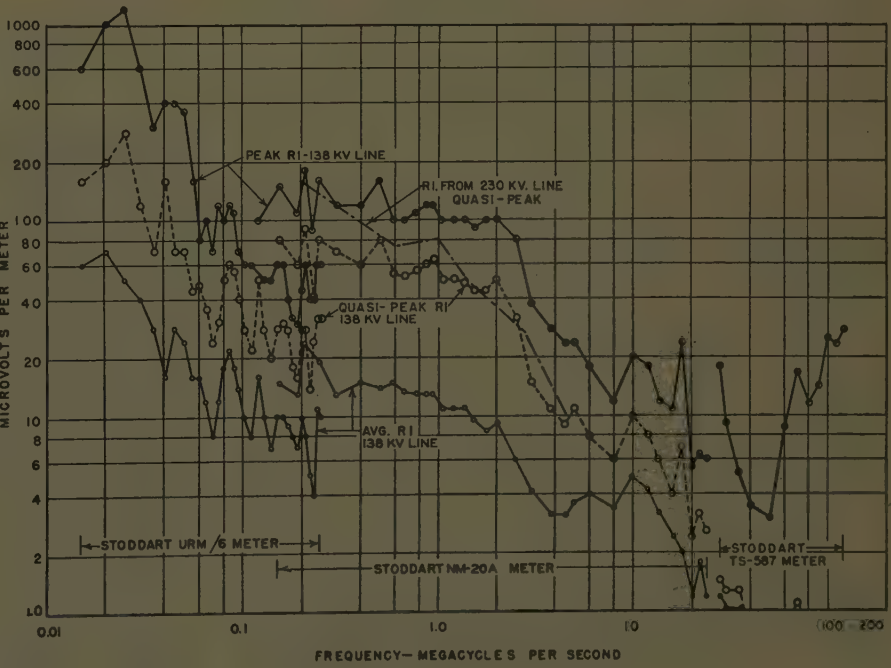


Figure 7. R. I. variation with frequency on operating lines

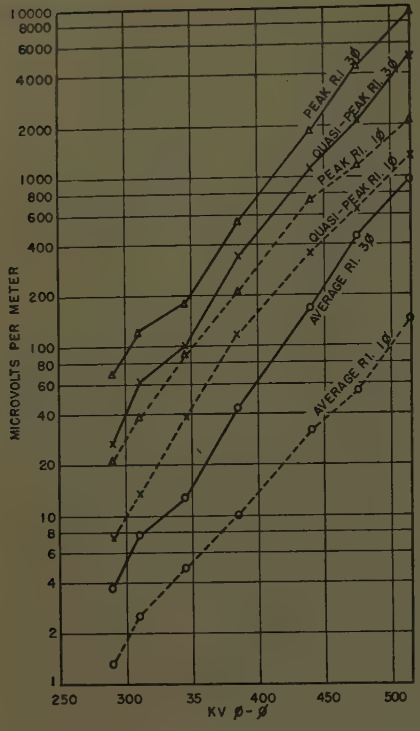


Figure 8. R. I. correlation to single-phase and 3-phase runs. Stoddart NM-20A radio noise meter

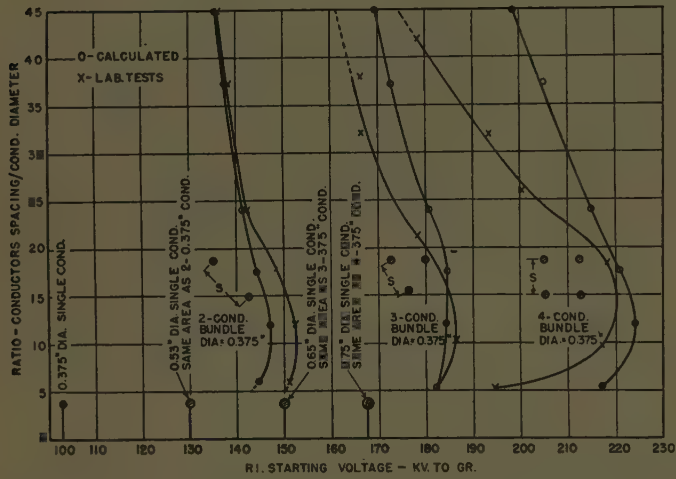


Figure 9. R. I. threshold voltages for bundles of smooth conductors from laboratory tests

when it is raining. The rate at which the R. I. decreases as the conductor dries decreases with the voltage on the conductor.

11. The relation between conductor diameter and voltage for radio-frequency field intensities above the threshold values is of the same form as the threshold relation.

12. R. I. as measured at any one location changes even in fair weather by several times. This is believed to be mainly due to the shifting along the conductor of the corona bursts.

13. R.-I. characteristics of line conductors under service conditions can now be predicted from laboratory tests.

14. It is believed that the R.-I. characteristics of a conductor to be used on an operating line can be determined from the data presented here. These data, together with field experience in the region proposed fo transmission line, may be used as a basis for selecting conductor.

15. The effects of changes in relative humidity, tempe ture, and pressure as encountered at Tidd are not sign cant.

16. The change from 45-foot to 32-foot conduc spacing at Tidd was to increase the R. I. by 14 per ce This corresponds to an increase in voltage of 2 per ce whereas the calculated increase is 5 per cent.

17. Laboratory tests showed a bundle of two 0.92-in diameter stranded copper conductors has the same R. as a 1.4-inch-diameter steel-reinforced aluminum-cab conductor under dry conditions, and the same R. I. as 2-inch-diameter steel-reinforced aluminum-cable condu tor when wet.

18. R.-I. variation along a transmission line at 1 feet from the outside conductor is not significant for li design.

19. Smooth, weathered conductors when dry have t same R. I. at 10 per cent higher voltage than strand conductors of the same diameter. They have the sa R. I. under wet conditions.

20. No appreciable difference in R. I. was observ between horizontal and vertical line conductor configur tion or between single- and double-circuit lines.

21. At ground level the R.-I. field intensity readin were not affected by grounding or isolating the static wir

22. R. I. decreases inversely with frequency over t range of 0.015 to 400 megacycles covered by tests.

23. Although corona and R. I. start at the sa voltage, corona loss after it reaches a significant val increases much more rapidly than R. I. with increase voltage, while R. I. has significant values at the low voltages where corona loss is negligible.

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Shunt Capacitors for Transmission and Distribution

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N THE PERIOD following World War II, shunt capacitor banks totaling in capacity approximately 225,000 re- ctive kva were installed on the system of American Gas and lectric Company. At distribution stations, 24 switched nd unswitched banks, ranging in voltage from 2.3 to 13.8 v and in size from 720 to 20,100 reactive kva, were pro- ided. At transmission stations 12 outdoor capacitor anks, ranging in voltage from 22 to 44 kv and in size from ,075 to 19,800 reactive kva, were installed.

Most of the low-voltage installations are in two or more teps and are switched on and off under voltage control. ll of the most recent units are of the housed-cabinet type, ince this arrangement is found to be most economical and rovides advantages of prompt delivery, quick installation, nd possibility of later relocation at small expense. The enefits of providing reactive kilovolt-amperes in this man- er at distribution stations have become obvious to almost veryone in the last five years. The high-voltage banks vere found to be desirable for several reasons.

1. Lower cost when capacity is required in a large mount at a given location, as compared to the provision of witched low-voltage banks at several locations in an area.
2. Where heavy power interchanges on the 132-kv ystem are causing low-voltage conditions at transmission tations, the use of large capacitor banks during these eriods maintains reasonably satisfactory voltage levels.
3. When used in conjunction with existing synchronous ondensers or voltage-regulating transformers, high-voltage anks provide an increase in the voltage level necessary to ermit the existing equipment to operate in its normal oltage-regulating range.

In connection with high-voltage banks, capacitors of standard voltage ratings were used because there were considerable savings in cost and greater availability for quick replacement, as compared to special 6,900-volt units.

igure 1. A 6,600-reactive-kva 45,700-volt capacitor bank at ikegrady Station (near Elkhorn City, Ky.) of the Kentucky and West Virginia Power Company, Inc.

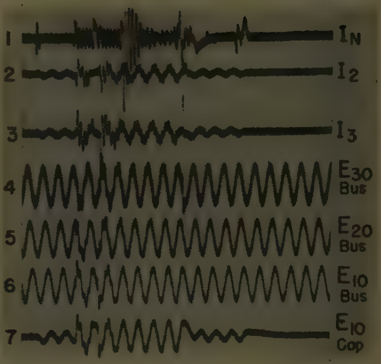

Figure 2. Oscillogram of energizing and immediate de-energizing of 9,900 - reactive - kva 45,700-volt capacitor bank at Sprigg Station of the Appalachian Electric Power Company

For instance, for 44-kv operation, each phase in the bank is made up of four parallel groups in series, utilizing 7,200-volt capacitors in each of the first three groups and 4,800-volt units in the fourth group. The three groups of each phase are Y-connected, thus obtaining a voltage rating of 45.7 kv. A view of such a typical 45.7-kv bank connected to a 44-kv line in a remote location near Elkhorn City, Ky., is shown in Figure 1. A voltage limit of 110 per cent has been used to determine how many capacitors may be allowed to fail in a series group before automatically tripping the bank out of service. Experience over several years has indicated that capacitor failures are quite rare; therefore, banks may be designed and control provided on the basis of staying in service after failure of one capacitor in a group and of de-energizing the bank in case of failure of two capacitors in a group.

Most of the high-voltage banks are switched with circuit breakers having 8-cycle tripping speed and utilizing special interrupters with resistors momentarily shunted across the contacts when closing and opening the circuit breaker. Tests made originally on several typical banks, and operation since then, have demonstrated that overvoltages during switching are kept below twice normal and that satisfactory and reliable results are obtained with this arrangement.

Magnetic oscillograph records of the currents and voltage during tests in such a 45,700-volt capacitor bank are shown in Figure 2.

Extremely large savings result by utilizing these high-voltage banks, particularly when installed in conjunction with synchronous condensers and step-type regulating transformers, since in these cases the installation of additional and larger and also more expensive equipment is obviated.

Digest of paper 51-15, "Application of Shunt Capacitors at Transmission and Distribution Stations," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Rural Line Sectionalizing by Repeater Fuses

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REPEATER fuses have been used by the Northern Indiana Public Service Company for sectionalizing distribution lines for the last 15 years. Studies have been made for all districts, and single line maps have been prepared for distribution to the various operating departments showing the location and recommended fuse link size for all sectionalizing points.

The operating plan is based on the premise that a maximum number of sectionalizing points, consistent with proper selectivity between sections, will confine trouble to the smallest area and that 3-shot repeater fuses will restore service after most cases of trouble.

Co-ordination of 3-shot repeater fuses means that all three fuses on one repeater will blow before one fuse on the next repeater nearer the source of supply will blow. This means that there must be definite steps in the size of fuse link used in any number of sectionalizing points in series in a line. It also means that the links at the farthest point in the circuit must be as small as possible to avoid the use of too large a fuse at the beginning of the sectionalized line.

The smallest size fuse link possible for each size distribution transformer is being used in order to be able to use small sectionalizing fuses. The transformer lightning arresters are connected on the line side of the transformer fuse so that a lightning-arrester operation cannot cause a transformer outage.

Consideration must be given to all pertinent factors in locating sectionalizing points. Importance of the load served in an area, unusual hazards to the line, inaccessibility for repairs, bad tree conditions, size of load to be picked up after a prolonged outage, and any other special conditions will determine locations for either an operating or a service standpoint.

Replacement of blown fuses has been taken care of without regularly scheduled patrols. All employees are instructed to report blown fuses found in the course of their regular work, and special patrols are made after every storm. This method of operation, together with the fact that 3-shot fuses will restore service for two transient faults before a total interruption occurs, has proved satisfactory.

Data have been accumulated for the past 11 years from the daily records of one of the representative districts, and these data have been analyzed from time to time.

At the present time there are 384 miles of line in the representative district, protected by 144 3-shot repeater fuses at 113 sectionalizing points. The fuse sizes used range from a minimum of 2 amperes to a maximum of 40 amperes, with 32 of them 5 amperes or less.

Over the 11-year period analyzed, 2,940 fuses have blown from 1,266 cases of trouble, and the record shows that most installations have not had more than three cases of trouble in any 2-year period.

The major causes of trouble, lightning, tree limbs, and lightning arresters, accounted for 62.7 per cent of all case reported. Analyses of these causes are as follows:

1. *Lightning.* 1,010 fuses blown in 595 cases of troubl All three fuses blown—24 per cent of cases. One or tw fuses blown—76 per cent of cases.

Lightning is used in the sense of the initiating caus since the actual cause of fuse blowing is the 60-cycle curre which flows over a path ionized by the lightning strok Exceptions may occur in rare cases, but the probability a sufficiently high current stroke discharging through a fus to ground is very small.

2. *Tree Limbs.* 648 fuses blown in 240 cases of troubl All fuses blown—82 per cent of cases. One or two fuse blown—18 per cent of cases.

Information from the field shows that in most cases trouble tree limbs must be removed before service can restored, and 18 per cent successful reclosure is as good can be expected.

3. *Lightning Arresters.* 221 fuses blown in 221 cases trouble. All fuses blown—88 per cent of cases. One two fuses blown—12 per cent of cases.

Sectionalizing fuses seldom restore service after lightnin arrester failures but serve to localize the search for this typ of trouble which is so difficult to find.

Summarizing all cases of trouble, service was restore in 57 per cent of the cases by using 3-shot repeaters. 2-shot repeaters had been used, the successful reclosu would have been 41 per cent of the cases.

Improper operations have been reported in 60 case most of which, it is believed, resulted from causes that a not inherent faults in the equipment.

Estimated annual investment costs allocated to the ave age number of cases of trouble per year to compare 1-sho 2-shot, and 3-shot repeater fuses show that each case trouble could be sectionalized by using single-shot devic at a cost of $4.23 each; using 2-shot repeaters would resto service in 41 per cent of all cases of trouble at an addition cost of $14.80 each; using 3-shot repeaters would resto service in an additional 16 per cent of all cases at an add tional cost of $12.10 for each case of trouble.

No economic comparison is intended between 3-sh repeating fuses and other automatic sectionalizing device nor between this method of sectionalizing and alternati methods. As a result of experience and analysis of t records, it is believed that satisfactory results are bei obtained at a reasonable cost.

Digest of paper 51-112, "11-Year Operating Record—Rural Line Sectionalizing Repeater Fuses," recommended by the AIEE Committees on Protective Devic Relays, and Transmission and Distribution and approved by the AIEE Techni Program Committee for presentation at the AIEE Winter General Meeting, N York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transacti* volume 70, 1951.

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Structure and Properties of Ferrites

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Many advances have been made in the study of ferromagnetic ferrites in the past few years. This article discusses the Néel theory, in both the paramagnetic and ferromagnetic regions, and consequences and proof of the Néel theory.

IT IS THE PURPOSE of this article to review the advances made in understanding the ferromagnetic ferrites since the previous AIEE conference paper[1] on the subject of the ferrites. In order for this paper to be a coherent unit, a brief review of the crystal structure of the ferrites of interest will be given.

REVIEW OF THE CRYSTAL STRUCTURE OF FERRITES

THE FERRITES are not metallic but are chemical compounds with the general formula $M^{+2}Fe_2O_4$ where M^{+2} is a divalent metal ion. (It should be mentioned that lithium, a monovalent ion, can form a ferrite with the same general structure as discussed here. In order to satisfy the valence requirements, the formula of this lithium ferrite is $Li_{1/2}Fe_{5/2}O_4$. It has ferromagnetic properties and has been studied by Gorter.[2]) The divalent ions of importance to this discussion are Mg^{+2}, Cu^{+2}, Mn^{+2}, Ni^{+2}, Fe^{+2}, Zn^{+2}, and Cd^{+2}. The ferrites of these seven elements all have the same crystal structure, called the "spinel" structure. The spinel structure is cubic* and the arrangement of the ions is that of a close-packed oxygen lattice, face-centered cubic, with the other ions (for instance Mg^{+2} and Fe^{+3} in $MgFe_2O_4$) distributed in an orderly fashion throughout the spaces (interstices) left in this cubic lattice. Two varieties of interstices exist in the lattice. These differ in the number of surrounding oxygen ions and are referred to as (1) the tetrahedral interstices, and (2) the octahedral interstices. The spinel unit cell contains 32 oxygen ions, 16 ions in octahedral interstices, and eight ions in tetrahedral interstices. There are two varieties of spinels called (1) normal, and (2) inverse. In the normal spinels the divalent metallic ions occupy the tetrahedral positions and the trivalent ions (Fe^{+3}) occupy the octahedral positions. In the inverse spinels, the tetrahedral positions are occupied by trivalent Fe^{+3} ions and the octahedral positions are occupied jointly by the divalent and the remainder of the Fe^{+3} ions.

At the time of the previous article,[1] the following observations and rules had been made:

1. The ferrites exhibiting ferromagnetic properties are inverse spinels.
2. The ferrites showing no ferromagnetic properties are normal spinels.
3. The introduction of a normal (nonferromagnetic) ferrite into an inverse (ferromagnetic) ferrite in solid solution lowers the ferromagnetic Curie point.
4. Of the ferromagnetic ferrites only ferrous ferrite has a positive magnetostriction; the others have a negative magnetostriction.

Left unanswered at that time were some questions of fundamental importance. In particular, why should so marked a difference exist between the normal and the inverse spinels? Any theory which explains the ferromagnetic behavior of, for instance, copper ferrite must also account for the fact that zinc ferrite is nonferromagnetic.

Application of the Bethe and Slater criterion for the existence of ferromagnetism (that is, for positive interaction) in metals to the case of the ferrites is unrewarding. This criterion is based on a critical ratio of the atomic separation to the diameter of the unfilled 3 *d* shell. In the ferrites the distances between the various possible positions for the ions with uncompensated spins are:

tetrahedral-to-tetrahedral distance $= {}^1/_4 a\sqrt{3} = 0.433a$
tetrahedral-to-octahedral distance $= {}^1/_8 a\sqrt{11} = 0.415a$
octahedral-to-octahedral distance $= {}^1/_4 a\sqrt{2} = 0.353a$

where *a* is the unit cell edge length.

For instance, in magnesium ferrite *a* is 8.36 angstroms. The diameter of the ferric ion is about 1.34 angstroms. In magnesium ferrite the magnetic ion present is only the ferric ion and, in this inverse spinel, these ferric ions are found in both tetrahedral and octahedral positions. The ratios of the separations of the ions to the diameter are:

tetrahedral-to-tetrahedral:	3.61/1.34=2.70
tetrahedral-to-octahedral:	3.46/1.34=2.58
octahedral-to-octahedral:	2.95/1.34=2.20

These ratios are considerably greater than those for the ordinary ferromagnetic metals, but they are not greater than that for gadolinium, which is also ferromagnetic. However, the anomaly of the nonferromagnetic behavior of zinc ferrite ($a=8.42$) in which only octahedral positions are filled is not resolved on this basis.

THE NÉEL THEORY

NÉEL, IN AN exceptional analysis[3] of the characteristics of the ferrites, has developed a theory which appears

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* Divalent metals other than the seven listed, for instance, lead, may form compounds which possess the ferrite chemical formula but which do not crystallize in the cubic lattice. Crystal systems other than cubic lack this symmetry and possess inherently a crystalline anisotropy. This crystalline anisotropy then causes magnetic anisotropy over and above that to be expected for cubic lattices. As noted in reference 1, the initial permeability is the smaller, the larger the anisotropy.

Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Second in a series of two papers on magnetic materials at high frequencies. See "A Study of Nuclear and Electronic Magnetic Resonance," K. K. Darrow (*EE, May '51, pp 401–4*). The author wishes to express his appreciation to Dr. F. K. du Pré of Philips Laboratories, Inc., for helpful discussions concerning the material presented in this paper.

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to describe much of the behavior of these materials, and accounts for the ferromagnetic behavior of the inverse ferrites and for the nonferromagnetic behavior of the normal ferrites.

Aside from the real ingenuity underlying this development, a small part of Néel's success is due to the fact that he considered not only the ferromagnetic behavior of the ferrites but their paramagnetic behavior as well.

The features of this theory are that the magnetization of a ferrite is calculated as a function of temperature for the two cases: temperatures above the Curie point (paramagnetic) and temperatures below the Curie point (ferromagnetic). Néel's methods will be followed in the next two sections.

THE PARAMAGNETIC REGION

ABOVE THE Curie point, the ferrites, in common with other ferromagnetic substances, are paramagnetic. In order to understand Néel's development, a brief review of earlier considerations of paramagnetism may be useful.

The Langevin Classical Theory. The paramagnetic behavior of substances was first investigated by Curie who found that those substances studied by him obeyed a law which bears his name. This law states that the susceptibility varies inversely as the absolute temperature:

$$\chi_M = C_M/T \tag{1}$$

Here χ_M is the susceptibility of a mole of the substance; C_M is a constant, the Curie constant, for a mole of that substance; and T is the absolute temperature.

Langevin gave the Curie law a theoretical foundation. He considered a paramagnetic gas, each particle of which has a permanent magnetic moment so that, in a magnetic field, the particles tend to align themselves in the field. Thermal agitation prevents the complete alignment of the particles, and, on the basis of the Maxwell-Boltzmann law, Langevin derived the following relationship:

$$I_M = N\mu(\coth a - 1/a) \tag{2}$$

where a equals $\mu H/kT$.

Here, I_M is the magnetic moment per mole; μ is the magnetic moment of one molecule; H is the strength of the magnetic field acting; T is the absolute temperature; k is the Boltzmann constant; N is the Avogadro number; and coth a is the hyperbolic cotangent of a. This is written also as

$$I_M = N\mu \mathbf{L}(a) \tag{3}$$

by defining the Langevin function $\mathbf{L}(a)$ as the quantity $(\coth a - 1/a)$.

When a is small, then the relationship can be written

$$I_M = N\mu\left(\frac{\mu H}{3kT}\right) = \frac{N^2\mu^2}{3RT}H \tag{4}$$

since $Nk = R$, the gas constant.

Finally, because the susceptibility is the magnetization per unit field strength

$$\chi_M = \frac{I_M}{H} = \left(\frac{N^2\mu^2}{3R}\right)\frac{1}{T} \tag{5}$$

This is the theoretical Curie law, derived from classi theory. The molar Curie constant has the theoreti significance that it is

$$C_M = \frac{N^2\mu^2}{3R}$$

The Curie-Weiss Theory. Not all paramagnetic su stances obey the Curie law. Certain other substanc including some which are ferromagnetic at temperatu below a characteristic temperature (the Curie tempe ture), obey a second law, called the Curie-Weiss law

$$\chi_M = \frac{C_M}{T-\theta}$$

Here the quantities are the same as in the simple Cu law with the introduction of another constant, θ, which a characteristic temperature. For ferromagnetic elemen this is approximately equal to the Curie temperature.

Weiss derived this law by extending the Lange theory, assuming that an internal molecular field exi which is proportional to the intensity of magnetizati The field now acting in the body is not only the extern field but also this added internal field. With this sumption then, the H in equations 2 and 3 must be replac by an effective field

$$H_{\text{eff}} = H + cI$$

where H is the external field; c is a constant which, wh multiplied by I, the intensity of magnetization, yields t internal field.

The Langevin theory, with this substitution, and at hi temperatures (that is, above the Curie point), yields t following equations by the approximation for the Lange function when the argument is small

$$I_M = \frac{C_M}{T-\theta}H$$

$$\chi_M = \frac{C_M}{T-\theta}$$

corresponding to equations 4 and 5. Here C_M has t same significance as in equation 6 and

$$\theta = \frac{cN^2\mu^2}{3R}$$

The Quantum Theory. In the Langevin theory it assumed that the particles can take any orientation w respect to the field direction. However, the quant theory requires that only certain definite positions can assumed. When the quantum mechanical rules are plied to paramagnetic behavior, the molar magne moment is

$$I_M = Ngj\mu_B \mathbf{B}\left(\frac{gj\mu_B}{kT}H\right)$$

This is similar to equation 3. The difference betw this expression and that for the classical Langevin the is that (a) the elementary magnetic moment μ has b evaluated as the product $gj\mu_B$ (In this product, g is gyromagnetic ratio, j is the quantum number characte ing the total angular momentum of the atom in questi d μ_B is the fundamental magnetic unit, the Bohr magne-n.); (b) the Langevin function has been replaced by other, called the Brillouin function. This latter function ed not be presented here. It will suffice to note that, small values of the argument, equation 3A reduces o to the simple Curie law.

The Paramagnetism of the Ferrites. The paramagnetic operties of a number of ferrites were studied by Made-oiselle Serres.[4] The results do not fit the Curie-Weiss v and, of course, can not be expected to fit the simple rie law if the ferrite is ferromagnetic at lower tempera-es. Néel has extended the Weiss concept of the internal ld to the ferrites. It was done in this manner:

1. The development is for the case in which only one the two metallic ions in the ferrite is magnetic (that is, $^{+3}$).
2. It is not assumed that the ferrite is completely verted or normal, but that some arbitrary distribution ists. This distribution ratio becomes a parameter in e equations.
3. The magnetization of the ferrite is made up of two rts, the magnetization due to the Fe^{+3} ions in the tetra-dral position and the magnetization due to the Fe^{+3} ions the octahedral position. (It is reasonable that these agnetizations may be different since the oxygen sur-undings are different in the two positions.)
4. No assumption is made as regards the signs of the efficients of the molecular fields. (If the sign is positive, is indicates a positive exchange integral and the spins of e interacting ions tend to be aligned. If negative, this dicates a negative exchange integral and the spins of e interacting ions tend to be antiparallel.)

Condition 2 in the steps just outlined is represented as lows: Let a fraction λ of the Fe^{+3} be in the tetrahedral, position and the remaining fraction μ be in the octa-dral, B, position. That is

$$-\mu=1 \qquad (12)$$

a normal spinel $\mu=1$; in an inverted spinel $\mu=1/2$.

For condition 3, the total magnetization is the sum of e magnetization due to the Fe^{+3} ions on each position

$$=\lambda I_A+\mu I_B \qquad (13)$$

here I_A and I_B are respectively the magnetic moment a gram ion of A ions (Fe^{+3} ions in tetrahedral surround-gs) and a gram ion of B ions (Fe^{+3} ions in octahedral rroundings).

As in the Weiss treatment, the field acting in the body is e sum of the external and the internal fields, see equation But now there must be two internal fields, one due to e moments in the A positions and the other due to those the B positions. These two internal fields may act fferently upon the ions in the A positions and upon the ns in the B positions. The differences will appear in the efficients which will be equivalent to the single coefficient, in equation 8. In this way, and with strict analogy to eiss, Néel writes

$$\begin{aligned} {}_A&=n(\alpha\lambda I_A+\epsilon\mu I_B) \\ {}_B&=n(\beta\mu I_B+\epsilon\lambda I_A) \end{aligned} \qquad (14)$$

for the internal field acting upon an A position, H_A, and for the internal field acting on the B position, H_B. Here $n\alpha$ is the internal field constant for the interaction of ions A on A; $n\beta$ is the constant for ions B on B; and finally, $n\epsilon$ is the constant for ions A on B (or B on A, which is reciprocal). Note that ϵ is assigned only two values, $+1$ and -1. This fixes condition 4 in the steps outlined previously. Of course, the internal fields depend upon the numbers of ions involved, and this is accounted for by the factors λ and μ.

Still in keeping with the Weiss concept, the total field acting is introduced into the Curie law, giving two equations for the two moments

$$\begin{aligned} I_A&=\frac{C}{T}(H+H_A) \\ I_B&=\frac{C}{T}(H+H_B) \end{aligned} \qquad (15)$$

By eliminating I_A, I_B, H_A, and H_B, equations 13, 14, and 15 yield a relationship between I_M, H, and T. This in turn will give the susceptibility χ_M (since it is the ratio of I_M to H) as a function of T.

The solution reduces to this equation

$$\frac{1}{\chi_M}=\frac{T}{C}+\frac{1}{\chi_0}-\frac{\sigma}{T-\theta} \qquad (16)$$

When $\epsilon=-1$, which turns out later to be the choice in ϵ which furnishes solutions in agreement with experiment, then

$$\begin{aligned} \frac{1}{\chi_0}&=n(2\lambda\mu-\lambda^2\alpha-\mu^2\beta) \\ \sigma&=n^2C\lambda\mu(\lambda(1+\alpha)-\nu(1+\beta))^2 \\ \theta&=nC\lambda\mu(2+\alpha+\beta) \end{aligned} \qquad (17)$$

C is the Curie constant, which according to the quantum theory, is different from equation 6, being equal to $N^2g^2j(j+1)\mu_B{}^2/3R$. Mademoiselle Serres' paramagnetic data have been fitted to equation 16, and the agreement between the calculated and the experimental susceptibilities is very good except near the Curie point.

Note that fitting experimental results into equation 16 yields values for the three constants χ_0, σ, and θ. But note also that equations 17 relate these three to the four parameters, n, λ, α, and β.

Thus, although the theory up to this point furnishes a description of the paramagnetic behavior, it does not permit of the complete description of the ferrite. Therefore, it becomes necessary to carry the development into the ferromagnetic region (temperatures lower than the Curie temperature). Equation 16 fails near the Curie point and, indeed, at a temperature T equal to θ the equation is useless.

THE FERROMAGNETIC REGION

IN DERIVING the Curie-Weiss law for paramagnetic behavior according to the classical theory, the approximation is made that the Langevin function, L(a), is equal to $a/3$ (or according to the quantum theory, that the Brillouin function B(a) is equal to $[(j+1)/j][a/3])$ when a is small. This approximation is not justified if

a is not small, for instance, at lower temperatures. Under this condition the complete function must be used, and when this is done it is possible to calculate the ferromagnetic spontaneous magnetization (or, for practical purposes, the saturation magnetization) as a function of temperature.

Again the Weiss technique is transferred by Néel to the ferromagnetic region of temperatures. The fundamental equations he uses are

$$I_S = \lambda I_{AS} \pm \mu I_{BS} \tag{13A}$$

depending upon whether $\epsilon = +1$ or -1.

$$\begin{aligned} H_A &= n(\alpha\lambda I_{AS} + \epsilon\mu I_{BS}) \\ H_B &= n(\beta\mu I_{BS} + \epsilon\lambda I_{AS}) \end{aligned} \tag{14A}$$

$$\begin{aligned} I_{AS} &= M\mathrm{B}\left(\frac{MH_A}{RT}\right) \\ I_{BS} &= M\mathrm{B}\left(\frac{MH_B}{RT}\right) \end{aligned} \tag{15A}$$

These equations are analogous to the corresponding equations in the paramagnetic case excepting for (a) the subscripts S which mean the saturation magnetization (that is, the spontaneous magnetization), (b) the approximation made in writing the paramagnetic equations 15 is not justified and the complete expression for the Brillouin function must be used, and (c) $M = gj\mu_B N$.

The complexity of the problem now is great. Néel analyzes experimental results on ferrites for both the paramagnetic and ferromagnetic regions of temperatures in the light of the equations derived when $\epsilon = -1$ and also when $\epsilon = +1$. The procedure consists in altering the parameters until agreement is obtained between the theory and experiment. When this agreement is obtained the values of the parameters λ, α, β, n, and ϵ are known.

THE CONSEQUENCES OF THE NÉEL THEORY

SOME NEW FACTS concerning the structure and properties of the ferrites are now apparent in the light of this theory. These are:

1. The ferrites previously considered to be inverted are not necessarily in the completely inverted form.
2. The chief interaction causing ferromagnetic behavior is that between magnetic ions in the tetrahedral positions and those in the octahedral positions. Compared with this interaction, that between the ions in the tetrahedral positions is small as is that between the ions in the octahedral positions.
3. The interactions are negative* (antiparallel arrangements of the spins).
4. Ferromagnetic behavior occurs when the tetrahedral and the octahedral positions are both occupied by magnetic ions in unequal numbers.
5. It can be seen qualitatively that zinc ferrite should be nonferromagnetic because here only octa-octahedr positions are occupied by magnetic ions, and this inte action is small.

EXPERIMENTAL PROOF OF THE NÉEL THEORY

IN THE FERROMAGNETIC region, proofs of the theory a to be looked for in the saturation behavior of tl ferrites.

The magnetic ions of interest in the ferrites are liste here together with the numbers of elementary magnet moments (Bohr magnetons) associated with each.

Ion	Fe^{+3}	Mn^{+2}	Fe^{+2}	Ni^{+2}	Cu^{+2}
M_s, Number Magnetons*	5	5	4	2	1

In order to estimate the total magnetic moment saturation at absolute zero for one molecule of the ferrit a simplification of the theory can be made. A rule ma be adopted which ignores the smaller A-A and B-B inte actions and which specifies merely that the spins a oppositely directed in the tetrahedral position from tho in the octahedral position. Thus, in nickel ferrite, a inverse spinel:

tetra	octa	
Fe	Ni Fe	O_4
⟵	⟶⟶	

Setting down the number of Bohr magnetons associate with each ion and supplying positive or negative signs indicate the opposition of the spins, we obtain:

$$\begin{array}{cccl} \mathrm{Fe} & \mathrm{Ni} & \mathrm{Fe} & \\ -5 & +2 & +5 & \longrightarrow 2\mu_B \end{array}$$

The value[2] obtained by experiment** is 2.3 μ_B. Althoug this agreement is not perfect, in the absence of this theo one could only sum all the moments present, arriving 12 μ_B.

In the case of copper ferrite, the saturation magnetizatic depends upon heat treatments. When quenched fro a high temperature, the saturation moment is 2.3 whereas if it is slowly cooled the value is 1.3 μ_B. On th basis of the theory this is explained by an exchange copper ion for the ferric ion in the tetrahedral positio While the agreement between different workers[2,3,6] on th degree of this interchange is not good, the changes saturation are qualitatively in the correct order to explained by the fact that the more random distributic will occur at the higher temperatures.

The saturation moment observed for magnesium ferri

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* To workers active in the field of ferromagnetism, the subject of antiferromagnetism may be unfamiliar. This is because antiferromagnetism was first recognized in paramagnetic substances which showed no ferromagnetic behavior. Néel[6] in 1932 recognized the fact that the unusual behavior of certain paramagnetic substances could be explained by the assumption of a negative interaction of spins. In the substances first investigated, however, there are equal numbers of spins in, say, the east and west directions. This results in a cancellation of any ferromagnetic behavior. Néel's theory, which is the basis of this report, is the first instance of the explanation of a ferromagnetic behavior due to an unbalance in the numbers of east and west spins. Néel suggests that this type of ferromagnetism is sufficiently different to require a new name, "ferrimagnetism."

* These are based on the number of $3d$ electrons in the ions and Hund's rule; the together furnish the spin quantum number, S. The product of S with the gyromagne ratio ($g = 2.0$) is the number of Bohr magnetons associated with the ion. This negle any orbital moments.

** The number of Bohr magnetons per molecule is related to experimentally observ quantities as follows:

Saturation magnetic moment per mole, $M = (gj)\mu_B N$, as in equation (3A), but saturation moment is usually measured per cubic centimeter and expressed in gau with customarily the symbol I_S. The relation between I_S and the number of Bo magnetons, that is, the product gj, is then:

$$I_S = \frac{(gj)\mu_B N}{\text{molecular weight}} \times \text{density}$$

an only be accounted for by supposing that this ferrite s not completely inverted. The observed moment can e explained if about 10 per cent of the magnesium ion s to be found on the tetrahedral position.

In the case of mixed ferrites containing zinc, the theory ives the approximate variation of the saturation moment t absolute zero for variation in the zinc concentration vhen the zinc concentrations are not too high. Figure 1 aken from Gorter's[2] paper illustrates this. The system f straight lines dotted in this drawing and extrapolated o 10 at 100-per cent zinc ferrite, is based on the theory, out ignores the fact that as 100-per cent zinc ferrite is pproached, the concentration of magnetic ions in the etrahedral positions decreases to zero at pure zinc ferrite. The equation for these straight lines is derived as follows: et the mole fraction of zinc ferrite be a. The formula hen may be written:

tetra	octa	
$Fe_{(1-a)}Zn_a$	$M_{(1-a)}Fe_{(1+a)}$	O_4

Applying the simplified rule, subtract the total number of Bohr magnetons in the tetrahedral position from the number in the octahedral position:

$$5(1+a)+M_{S_{Me^{2+}}}(1-a)-5(1-a)=M_{S_{total}}$$

or

$$M_{S_{total}}=(10-M_{S_{Me^{2+}}})a+M_{S_{Me^{2+}}}$$

As will be noted from Figure 1, the agreement at low zinc concentrations is satisfactory. The deviation at higher concentrations occurs because of the oversimplification. Néel[7] has succeeded in obtaining a better representation of the behavior of mixed ferrites which will not be discussed here.

SUPEREXCHANGE

In conclusion, attention should be drawn to a recent theoretical paper by Anderson.[8] This paper is concerned with the mechanism of the exchange in certain paramagnetic oxides which exhibit antiferromagnetism. Kramers[9] first proposed that coupling between the spins of magnetic ions can take place through the agency of another ion (for instance, oxygen) located in the lattice between the magnetic ions. This is referred to as "superexchange." Anderson's study, although based on a simpler structure than the spinel, carries some conclusions which are of interest in respect to the ferrites, for in the ferrites the same type of exchange acts as in the antiferromagnetic oxides. These conclusions are:

1. When oxygen ions are the intermediary through which superexchange occurs, the strongest interaction is between the magnetic ions situated along a straight line through the oxygen ion. That is, the angle made in the lattice between the magnetic ions through the oxygen is 180 degrees.

The weakest (and perhaps even zero) interaction is between magnetic ions situated at 90 degrees with respect to the oxygen.

These conditions are the more likely to be fulfilled if the bonding in the compound is not fully ionic because in the derivation the energy of transfer of an electron from oxygen to the magnetic ion must be small for the exchange interaction to be strong.

2. Whether the interaction is positive or negative depends upon the electron configuration of the d shell of the interacting magnetic ions. If the d shell is less than half complete (that is, fewer than five electrons in the d shell) the interaction is positive. When the d shell is half or more complete, the interaction is negative.

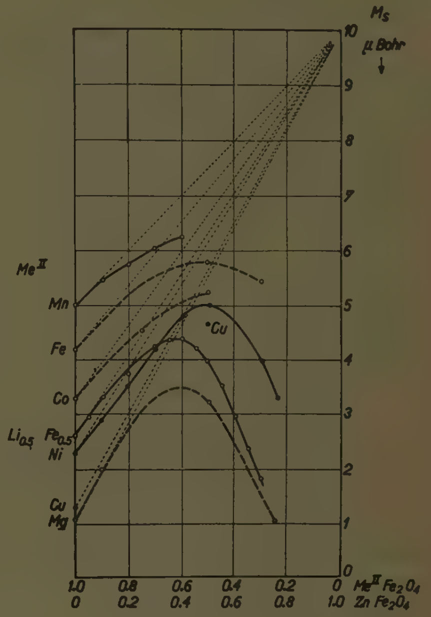

Figure 1. Variation of the saturation moment at absolute zero for variation in the zinc concentration

The first conclusion is of interest here because Néel finds that the tetrahedral-octahedral interaction is the important one. Inspection of the ferrite structure shows that the angle between the A and B positions through the intervening oxygen ion is about 125 degrees, with the spacings:

A to oxygen	0.216 a
B to oxygen	0.250 a

or, if a slightly more removed B ion is considered, the angle is 180 degrees with the spacings:

A to oxygen	0.216 a
B to oxygen	0.433 a

The angle made between two A positions through an intervening oxygen ion is about 80 degrees, with the spacings A to oxygen of 0.216 a and 0.415 a.

Finally the angle between two B positions through an intervening oxygen is 90 degrees with the B to oxygen spacing of 0.250 a. Note that in zinc ferrite the B positions are the ones occupied by magnetic ions. The nonferromagnetic character of zinc ferrite appears to be consistent with the conclusion that a 90-degree placement results in small, or even zero, interaction.

The second conclusion is also consistent with the behavior of the ferrites, for the interactions are negative and the ions involved have d shells half or more complete.

There is one recent[10] example of positive interaction between magnetic ions in an oxygen lattice which yields, of course, ferromagnetic behavior. In these compounds the magnetic ions are Mn^{+3} and Mn^{+4} and here the *d* shells are less than half filled. These compounds do not have the spinel structure of the ferrites and will not be discussed further here.

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Compensation of A-C Instruments for Variations in Frequency

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The range of frequencies for which a meter can be used within given error limits has been increased nearly tenfold. This has been accomplished by compensating the meter with a capacitor shunting its series resistance; the value of the capacitor is determined by a rigorous solution of the meter circuit.

ALTHOUGH numerous papers and references[1–5] are available on the subject of frequency compensation of a-c instruments in the higher power frequencies, up to 5,000 cycles, most such references appear to be limited to a given design or range in voltage or frequency. A general solution for one type of voltmeter compensation is presented here.

Voltmeters of both the electrodynamometer and iron-vane type are fundamentally milliammeters. When in series with a suitable resistance they respond to the applied voltage. However, they have an inherent inductance as well so that as the frequency is increased the impedance rises and the instrument reads low. If the inductance is reduced by using fewer turns on the actuating coil or coils, the instrument takes more current for normal torque to the point where the power which must be dissipated is limiting.

The effect of the inductance on the instrument accuracy may be compensated by a c pacitor shunted across a po tion of the series resistanc This is discussed by Dr dale and Jolley,[1] who gi the fundamental equatio However, instead of obta ing a rigorous solution, approximation is indicat which is of little use because it does not take into accou any particular frequency range, and certain instrume may be much overcompensated if the approximation used and large errors may result.

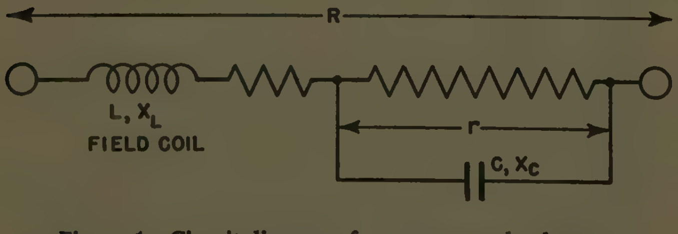

Figure 1. Circuit diagram of a compensated voltmeter

THE CIRCUIT

THE CIRCUIT given by Drysdale and Jolley is shown Figure 1. The impedance of this circuit is given b

$$Z=(R-r)+\frac{r}{1+C^2r^2\omega^2}+j\omega\left[L-\frac{Cr^2}{1+C^2r^2\omega^2}\right]$$

Note that if the absolute value of this impedance is ma the same as the resistance *R*, the current through the strument will be the same as at a low frequency approa ing direct current and the error at the higher freque will be zero, neglecting for the moment the effect Foucault currents in the iron vanes and incremental ductance as the pointer moves.

Full text of paper 51-30, "Frequency Compensation of A-C Instruments," recomme by the AIEE Committee on Instruments and Measurements and approved by AIEE Technical Program Committee for presentation at the AIEE Winter Ge Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in A *Transactions*, volume 70, 1951.

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Since it is usually desired to compensate the instrument for specific frequency, it will simplify matters somewhat to bstitute X_c for $1/\omega C$ and X_L for ωL. Equation 1 reduces

$$= R - r + \frac{X_c^2 r}{r^2+X_c^2} + j\left[X_L - \frac{r^2 X_c}{r^2+X_c^2}\right] \tag{2}$$

Taking the absolute value by the square root of the sum the squares of the in-phase and j values, we have

$$= \sqrt{\left[R - \frac{r^3}{r^2+X_c^2}\right]^2 + \left[X_L - \frac{r^2 X_c}{r^2+X_c^2}\right]^2} \tag{3}$$

Squaring and rearranging

$$= \sqrt{R^2 + X_L^2 + \frac{r^2(r^2-2Rr-2X_LX_c)}{r^2+X_c^2}} \tag{4}$$

CONDITION FOR COMPENSATION

IT IS OBVIOUS that if the sum of the factors to the right of R^2 equals zero, then $Z = R$ and the instrument reads corectly. Our criterion for exact compensation is, therefore, at in the circuit of Figure 1 the several constants be so osen that

$${}_L^2 + \frac{r^2(r^2-2Rr-2X_LX_c)}{r^2+X_c^2} = 0 \tag{5}$$

This may be expanded to

$${}_c^2X_L^2 - X_c(2X_Lr^2) + X_L^2r^2 - 2Rr^3 + r^4 = 0 \tag{6}$$

Solving equation 6 for X_c, we arrive at that value of capacy reactance which makes the entire network have the me value of impedance as its resistance, at the frequency question. There is a considerable phase angle which is ot a factor in a voltmeter; our concern is to obtain the me current in the actuating coil to obtain the same deection.

$${}_c = \frac{r^2 + r\sqrt{2Rr - X_L^2}}{X_L} \tag{7}$$

USE OF VALUES IN TERMS OF *R*

EQUATION 7 gives the value of capacity reactance for the indicated factors, and these, r, R, and X_L may be used ith their actual values. However, in this analysis and in e actual use of the equations and curves, it is found much mpler to express r, X_L, and X_c in terms of R. This allows r general solutions for different instrument mechanisms nd conversion back to exact quantities is relatively simple hen the final result has been obtained.

AN EXAMPLE

AS AN EXAMPLE of such compensation, a typical uncompensated Weston Model *433* instrument for 150 volts ay be considered, with values rounded off for discussion. this instrument the total resistance $R = 5{,}000$ ohms. he coil resistance is 1,000 ohms so that r may be a maxium of 4,000 ohms or 0.8 in terms of R. The inductance sociated with this instrument is 0.4 henry.

This instrument is designed fundamentally to be satisctory from 25 to 125 cycles and to have a frequency error nder the worst condition, at 125 cycles, of the order of 0.2 per cent. Using this method of compensation one may analyze what can be accomplished up to 1,000 cycles using this same mechanism.

The reactance of 0.4 henry at 1,000 cycles is 2,500 ohms and, in terms of R, $X_L = 0.5$. Solving equation 7 where $R = 1$, $r = 0.8$, and $X_L = 0.5$, it is found that $X_c = 3.14$, again in terms of R. Or, $X_c = 15{,}000$ ohms, and this value at 1,000 cycles is represented by a capacity of 0.01015 microfarad, which will compensate exactly the inductance at 1,000 cycles.

PRACTICAL APPLICATION

IT IS OBVIOUS, however, that it would be difficult to obtain a capacitor of some odd exact value, and, accordingly, a slightly larger capacitor may be used connected across a slightly smaller portion of the series resistance, since C can be increased a bit as r is lower. It can be shown, however, that the smallest available capacitor which will meet the requirements should be used across the largest value of r since this produces the flattest characteristic at lower frequencies.

In production, the required capacitor is solved for from available data on inductance and resistance of a given design. The instrument then is assembled, placed in circuit with two dial boxes in series to serve as calibrating resistance, calibrated on low frequency, 60 cycles, for example, by adjusting one or both boxes, and the scale drawn. A stock capacitor of the next higher value than indicated by the calculation is shunted across one dial box. The instrument now is standardized on a source of the higher frequency by varying the resistance of the box shunted by the capacitor, while varying the other box to maintain their sum resistance the same as at low frequency. The final values of resistance are recorded, and spools or resistance sheets are adjusted to those values and connected in place within the instrument.

ERRORS AT OTHER FREQUENCIES

SINCE in equation 4 the several factors to the right of R^2 represent the error introduced and are small with respect to R, the approximation that the error is half the sum of the terms to the right of R^2 can be used, or

$$\text{Error} = \frac{X_L^2}{2} - \frac{r^2(X_LX_c + Rr - r^2/2)}{r^2+X_c^2} \tag{8}$$

When $R = 1$ and other factors are in terms of R, the error is given directly in terms of the reading. When the compensation is perfect, this value, of course, reduces to zero. Note that in this equation for other frequencies the term X_LX_c is constant with frequency. Accordingly, in an analysis of the frequency errors in a compensated instrument, the numerator of the second term in equation 8 is constant and the only terms that vary are X_L^2 in the first term and X_c^2 in the denominator of the second term.

As an example of the frequency errors involved in a 150-volt instrument without compensation and with compensation, the errors in per cent of the reading are given in Table I. While these are calculated values, no difference could be discerned in actual tests of the final instrument.

Up to 1,100 cycles the compensated instrument has a fre-

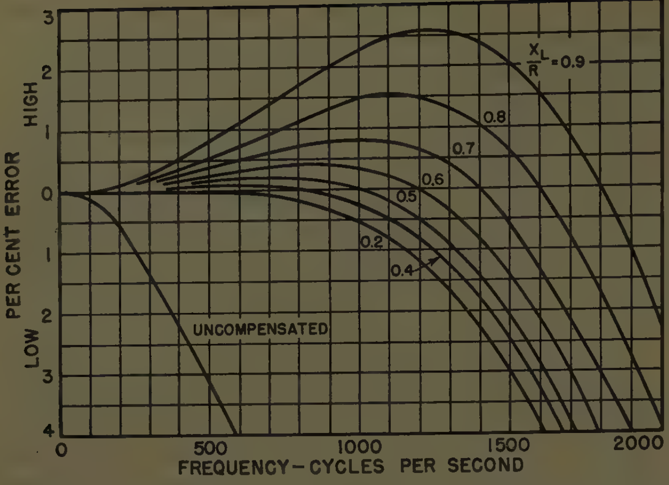

Figure 2. Frequency errors in 5,000-ohm voltmeter having 0.4-henry inductance and compensated at various frequencies; the curves are marked with the parameter X_L/R for the compensated frequency

Table I. Frequency Errors of Standard and Compensated Instrument

Frequency, Cycles per Second	Frequency Errors, Per Cent	
	Standard Instrument	Compensated Instrument
60	−0.05	+0.003
100	−0.13	+0.01
200	−0.50	+0.03
400	−2.00	+0.12
600	−4.50	+0.20
800	−8.00	+0.19
1,000	−12.50	0.0
1,200	−18.00	−0.50
1,400	−24.50	−1 49

quency error of less than 0.2 per cent whereas the standard instrument is within 0.2 per cent only up to 125 cycles. This gives a net gain of a nearly tenfold expansion of frequency coverage at the expense of a small capacitor. Similarly, the same instrument can be compensated at other frequencies to determine the extent to which the method may be used. In the example, if compensated at 400 cycles, $X_L/R=0.2$, and at 1,800 cycles $X_L/R=0.9$. The resulting instrument errors are shown in Figure 2. From these curves it will be noted that the error at 10 per cent above the compensated frequency is approximately equal to the greatest error at lower frequencies, hence it is customary to compensate at 90 per cent of the highest frequency to be covered in the interest of least error.

This general approach also allows for the use of curves to obtain the capacity values. Figure 3 shows the relation between the required capacity reactance at the compensated frequency as well as the actual capacity for the example cited, both for $r/R=0.8$. For other resistance ratios a family of such curves can be developed giving X_c/R for various values of X_L/R.

OTHER ERRORS

If the higher frequency adjustment is made at about 80 per cent of full scale, it will balance well at other points where the inductance is slightly different because of the position of the moving system. Only in the case of very h accuracy requirements—1/4-per cent instruments—doe scale error become a factor. Further, although this ana sis is on the basis of maintaining $Z=R$, a high-frequen error exists as a current meter, something less than 0.8 cent per 1,000 cycles for iron-vane instruments, much for electrodynamometers. But by actually calibrati the impedance is slightly overcompensated to give the sa end result.

MULTIPLE-RANGE INSTRUMENTS

Adding a series resistance multiplier to an instrum compensated as described will give an overcomp sated result; hence, unless the compensation has been sm it is necessary to use individual series resistors, each w its appropriate capacitor for multiple-range instrumen

FURTHER ANALYSIS

It can be seen from Figure 1, and can be proved by ar ysis, that the maximum frequency error in such a co pensated voltmeter, below the compensation frequen occurs at 70 per cent of that frequency. A formula for error has been derived from equation 8, but expressed terms of r and X_L. This allows for a rapid calculation of maximum frequency error up to the compensated point terms of r and X_L, each in terms of R.

$$\text{Error at } 0.7f=\frac{X_L^4}{8r^2+16r+16r\sqrt{2r-X_L^2}-4X_L^2}$$

where f is the compensated frequency.

Since the ratio of series resistance to total resistanc usually over 0.8 as required for temperature compensati we can assume $r=0.8$ in equation 9. This gives result errors for various values of the reactance in terms of total resistance shown in Table II; errors of the unco pensated instrument also are shown.

The errors resulting from various values of both X_L r in terms of R are plotted in Figure 4. Knowing the se resistance in terms of the total, and the reactance at the sired frequency in terms of the total resistance, an immedi indication of the maximum frequency error up to some per cent above the compensated frequency can be had inspection.

The importance of shunting the correcting capa

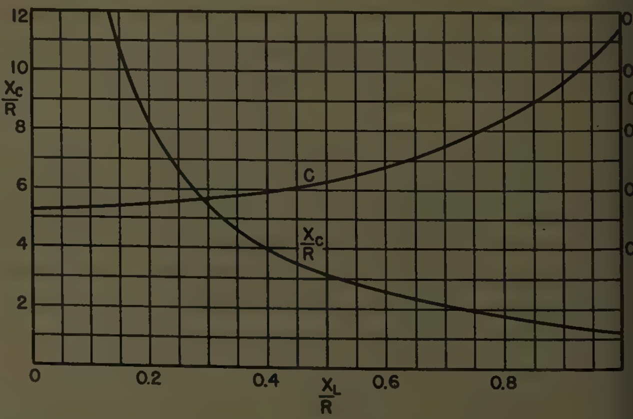

Figure 3. The relation between X_C and X_L in terms of indicated for $r/R=0.8$; C is also given for the cited examp

ross the maximum amount of series resistance also can be ted from these curves. For example, when $X_L/R=0.5$, he capacity is across 80 per cent of the total resistance, the aximum frequency error is about one-fifth as great as it ould be if shunted across only 30 per cent, assuming in both ses perfect correction at the compensated frequency.

It should be noted that this analysis is entirely in relative lues; hence it is applicable to all voltmeter ranges. As matter of interest, a 150-volt iron-vane or electrodyna-ometer instrument compensated to 1,000 cycles takes just der 0.01 microfarad, a 15-volt range takes 1.0 microfarad d a 1.5-volt range can be compensated with 100 micro-rads! And all ranges, if of the same proportions (that is, e same mass of coil copper and turns directly propor-nal to the voltage range), will have the same frequency ors in per cent.

Table II. Maximum Frequency Errors for r/R=0.8

/R	Errors in Per Cent Uncompensated Instruments	Errors in Per Cent Compensated Instruments
0	41.4	4.2
9	34.6	2.5
8	28.1	1.5
7	22.1	0.78
6	16.6	0.42
5	11.9	0.20
4	7.8	0.08
3	4.5	0.024
2	2.0	0.005
1	0.5	0.0003

LIMITS OF THE METHOD

N THIS EXAMPLE a standard mechanism was used, with moderate loss and normal torque. However, the induct-ce can be decreased materially through the use of fewer rns on the actuating coils, although this requires more cur-nt for a given voltage. To some extent this can be bal-ced by a reduction in torque to the point where a single-nge electrodynamometer instrument, for example, only ghtly subnormal in torque, and taking power somewhat in cess of normal, can be designed to be within 0.5 per cent full scale on direct current and at all frequencies from 25 4,000 cycles.

WATTMETER COMPENSATION

N A WATTMETER or varmeter both magnitude and phase angle of the current in the potential system are impor-nt. However, the moving coil of a wattmeter usually has ery small inductance and the current magnitude changes ry little; the phase angle may shift considerably, however, the higher frequencies, and is particularly important at w power factor. Phase-angle correction in the moving il circuit is obtained when, in equation 2, the *j* factor be-mes zero, or when

$$=\frac{r^2X_c}{r^2+X_c} \tag{10}$$

This cannot be done while at the same time maintaining e correct magnitude, but the fact is that the inductance in e moving coil of a wattmeter is so small that the magni-de error may be disregarded and correction made only for phase angle even though this does change the magnitude a very small amount. In the practical sense this is when X_L is less than $R/30$ and, when this is so, equation 10 may be reduced further to the approximate, though adequate, equation,

$$c=L/r^2 \tag{11}$$

This is the equation given in the literature for wattmeter phase-angle correction.

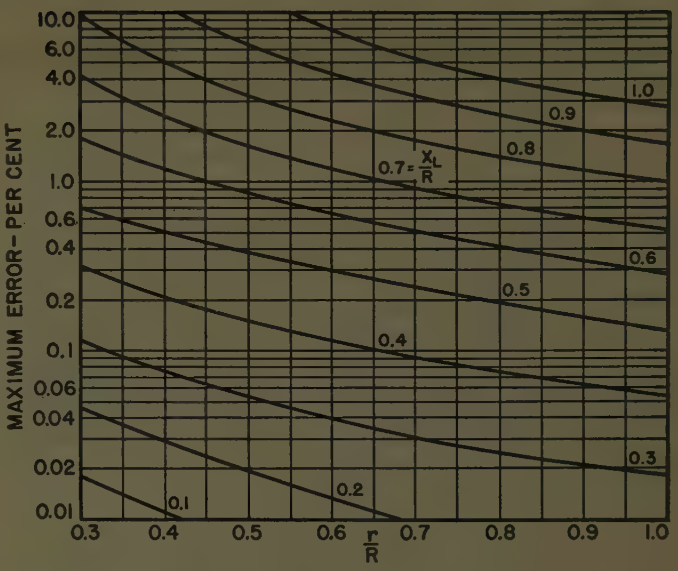

Figure 4. The maximum error up to the compensated frequency is shown in general terms

CONCLUSIONS

THROUGH the use of a rigorous solution of the network of a voltmeter, frequency compensated by a capacitor in shunt to its series resistance, it has been possible to evaluate easily the resulting errors at other frequencies for any given instrument. Placement of the data in curve form allows for immediate estimate of the error limits for any design and indicates those parameters which are controlling to any end requirement. Instruments compensated to 1,000 cycles are excellent for measurement of bad waveforms at lower frequencies, since they properly evaluate the higher harmonics.

With the approach described, an increase in frequency coverage of nearly ten is obtained with a given mechanism and with the original error limits. This is had at the cost of a suitable capacitor, a practical manufacturing procedure, and the necessary simplified engineering analysis of each design combination.

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Nondestructive Testing of Generator Insulation

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A-C DIELECTRIC-LOSS TESTS

TEST TECHNIQUES based on dielectric measurements at operating frequency, originally developed for higher voltage insulations, have been applied to the insulation of generator coils. The volt-ampere requirements of the test voltage source may be reduced materially by resonating the capacitance of the generator winding with a variable high-voltage inductor.

At operating voltage, the dielectric losses of generators rated 11 kv or above are composed not only of polarization and leakage losses, but also include appreciable ionization losses. Ionization losses result from the breakdown of minute voids within the coil insulation. Ionization may also occur at the surface of the coil in certain high-stress areas unless provisions have been made to reduce the stresses in these areas.

Ionization losses may be separated from the total losses mathematically if the assumption is made that the remaining losses vary with the square of the applied voltage. The measurement of ionization loss in a generator is important as a measure of the power available to attack the binding material in the coil insulation. The energy expended in ionization losses over a period of years should give some indication of the amount of ionization deterioration. It is probable that deterioration from ionization and from mechanical stresses incident to the operation of the machine acts to increase the number and size of the voids, and thereby increases the ionization losses.

RADIO-NOISE-INFLUENCE-VOLTAGE TEST

FURTHER DATA on ionization is provided by a field adaptation of the standard radio-noise-influence-voltage test. This test furnishes a check on the voltage at which ionization starts. It is also very sensitive to the disturbance which is created when a floating conductor is charged through a spark.

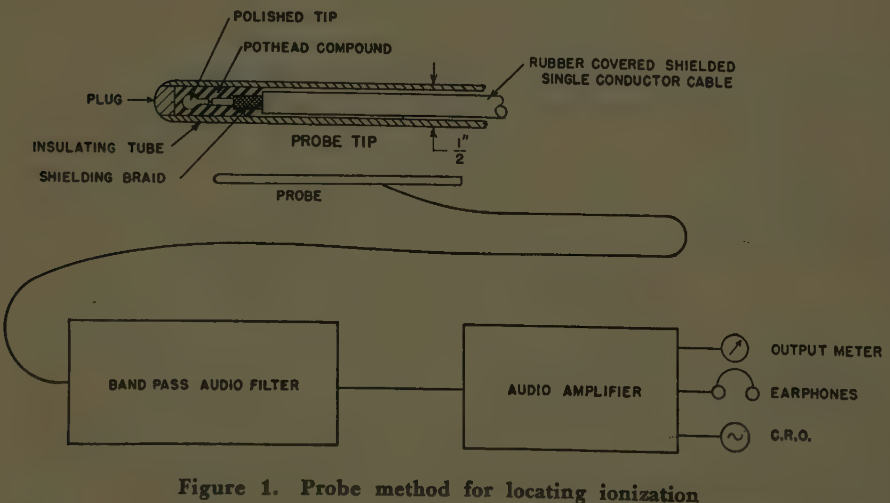

Figure 1. Probe method for locating ionization

PROBE TEST

AREAS AT which ionization exists can be located wit probe, providing the areas are accessible to the pro Removal of the end bells permits probing of the end tu The effectiveness of any anticorona treatment applie this area thus is determined readily. Figure 1 include detail of the construction of the probe.

D-C TESTS

STANDARD VALUES for the 1-minute resistance of mach insulation have been established and published cently.[1] The 1-minute resistance reading may be seriou affected by the time constant of the test circuit compri of the capacitance of the generator winding and equivalent series resistance of the measuring circ including the resistance of the test voltage source and series protective resistors. Based on a winding capacita of one microfarad, calculations indicate that the se resistance should be ten megohms or less to obtain a reas able accuracy for the 1-minute reading.

Generator insulation shows a marked absorption eff The 1-minute resistance is usually much lower than t measured near the completion of the absorption eff The ratio of the 10-minute resistance to the 1-min resistance has been found a very useful index for compar results on various generators. The index is particula valuable in determining the dryness of the insulati The effect of moisture on the index is to lower its value

CONCLUSIONS

THE VARIATION of d-c resistance with time, the variat of dielectric loss with voltage, the radio-noise-influe voltage, and the results of the probe examination all useful information for judging the condition of the insu tion and are therefore helpful in determining maintena procedures. The development of these nondestruc test methods gives ample basis claiming that knowledge of the erating conditions of generator sulation has greatly increased du the past several years. Whet this information is sufficient to dict the life of generator insula yet awaits the confirmation of ti

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Routine Insulation Testing of Synchronous Machines

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THE CONTINUOUS operation of large synchronous machines and freedom from failures in service is of tal interest to every electric utility company. One of the ajor causes of unpredicted and unscheduled outage is the ilure of stator coil insulation.

About eight years ago the engineers of the Southern alifornia Edison Company began to develop a routine spection and test procedure which would minimize or minate failures of windings in service. The first step was develop a procedure for routine physical inspection.

In addition to the physical inspection, insulation re-tance measurements are made of both stator and rotor. Records of the conditions found during these inspections e kept for all machines so signs of developing troubles ll be brought to attention and corrected or an estimate n be made of the risk of continuing operations.

In spite of careful visual inspections, measurements of nding resistance, and the maintenance program, some ilures in service occurred, and it was decided to supple-ent the inspections with electrical tests.

The nature of insulation failures in machine windings akes it practically impossible to predetermine the exact ne of failure. This condition has long been recognized the industry, and effort has been made to discover some nple and reliable nondestructive test that would measure d show the condition of the winding insulation.

Before establishing a routine procedure of overvoltage sting, or determining the voltage to be used, a review of e existing literature on this subject was made, and various anufacturers were requested to furnish information con-rning available methods of fixing the life expectancy of ndings by nondestructive tests which could be made the time of overhaul and to comment on the use of an nual 150-per cent overpotential test.

Comments received in 1944 indicated that the manu-cturers did not know of any nondestructive tests that ould provide reliable indication that a winding would would not fail before the next scheduled outage. Re-ated overvoltage tests were not favored generally. The ain objection to repeated overvoltage testing was not the ssible damage due to application of 150 per cent of rated ltage, but rather from accidental sources of misapplica-n; that is, from distorted wave form of test voltage, rge voltages, or high-frequency voltages that might sult from spark gap breakdown or from arcing if the nding failed during the test.

A program of rewinding a number of machines with old d doubtful windings gave an opportunity to make field tests to determine what value of a-c test voltage could be applied periodically to find weak spots. It was planned to make repetitive overvoltage tests on these old windings at the time of removal. The results of these tests were to be used to establish a satisfactory overvoltage test value to be applied to all machines during the annual overhauls and to determine how many times this voltage could be applied without causing measurable deterioration of the windings. A proper voltage for such test should be high enough to cause failure during test if any spot in the winding were seriously deteriorated, but it must be low enough not to cause additional deterioration.

Another object of the tests on these old windings was to determine if high surge voltages or high-frequency oscillations would be set up either by flashover of the test sphere gaps or by breakdown of the winding under test.

Each time a large synchronous machine was rewound, repetitive overvoltage tests and oscillographic records were made while the windings were tested to failure. The first period of testing extended from 1943 to 1945, and information about the behavior of insulation under repetitive high-potential tests was obtained and analyzed.

From these tests it was determined that a value of 150 per cent of rated voltage would be satisfactory for an overvoltage test to be made on each scheduled overhaul. The procedure of routine testing at 150 per cent of rated voltage was put in effect in 1945. Experimental testing was continued as other machines became available.

Many tests were made by applying 150 per cent of rated voltage to the windings repeatedly and holding this voltage one minute each time. The test voltage then was increased progressively until breakdown of the windings occurred. These tests all confirmed that 1-minute hold tests at 150 per cent of rated voltage could be applied once each year for over 100 years without adversely affecting a good winding. Testing at voltages less than 150 per cent of rated or for less than one minute are considered insufficient.

Oscillograph records of test voltages made at the instant of spark gap flashover, at the instant of winding breakdown, and with manually created arcing grounds were made. High-speed records were obtained with a cold-cathode oscilloscope and by photographing the cathode-ray oscilloscope trace with a high-speed camera. Other records were obtained with a magnetic oscilloscope.

Since the adoption of the overvoltage testing program in 1945, 56 different large synchronous machines, including condensers, hydrogenerators, and turbogenerators, have been regularly tested at the time of scheduled outages. The maximum number of annual tests on any one machine is six. Winding failures have occurred in seven machines during routine testing. In all cases repairs were made without difficulty and the machines returned to service after passing the 150-per cent overvoltage test.

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est of paper 51-126, "Routine Insulation Testing of Synchronous Machines," ommended by the AIEE Committee on Rotating Machinery and approved by the E Technical Program Committee for presentation at the AIEE Winter General eting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE nsactions, volume 70, 1951.

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Application of Microwave Channel

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Microwave communication is becoming increasingly important in many industries. Many factors must be considered in the establishment of a microwave system; they include the selection of a frequency band, location of terminal sites, and calculation of free-space loss and other losses between equipment terminals.

MICROWAVE channels promise to become a vital part of the over-all communication networks on most power systems and in many industrial applications.[1,2] However, very little has been published to date on the practical methods of selecting and applying point-to-point microwave equipment. For this reason, it seems appropriate to present a discussion of some of the problems encountered in applying microwave channels, along with practical data and formulas that have been found useful in microwave application.

The establishment of a microwave channel requires consideration of a number of different factors. Among these is the selection of the frequency band to be used, the selection of the sites for the terminals, the calculation of the free-space loss between the antennas, which in turn influences the selection of the antenna size, and the calculation of other losses such as the loss between the transmitting and receiving equipment and the antennas. These and other factors will be discussed.

SELECTION OF FREQUENCY BAND

THE FEDERAL Communications Commission has assigned various frequency bands in the microwave region from 952 to 30,000 megacycles for commercial point-to-point service. These bands, not including those assigned exclusively for common carrier service, are shown in Figure 1. The bands that will be used initially by power systems and others will probably be the lower-frequency bands, 952 to 960 megacycles, 1,850 to 1,990 megacycles, 2,110 to 2,200 megacycles, 2,450 to 2,700 megacycles, and 6,575 to 6,875 megacycles. This is explained in part by the propagation characteristics of these frequencies as compared with the characteristics of higher frequencies.

952 to 960 Megacycles. Fading is least severe in this band, but antennas of a given power gain are larger than for higher bands. Several watts of power, more than adequate for good signal-to-noise ratio over most practical line-of-sight distances with antennas of reasonable size, can be generated in transmitters of more or less conventional design using crystal oscillators and frequency-multiplying stages. The only departure from conventional low-frequency practice tha
required is the use of tuna
cavities or tuned lines
stead of lumped-constant
onant circuits in the f
multiplying stages. Disc-
or "lighthouse" tubes, wh
are similar in their operat
to conventional tubes, can
used in the final stages, and therefore the use of klystr
or magnetrons is unnecessary in this equipment.

Solid-dielectric flexible coaxial cable can be used betw
the transmitter and the antenna with moderate losses
lengths up to several hundred feet, making it possible
install all equipment except the antenna indoors at grou
level. This band is narrower than the higher-freque
bands, but its 8-megacycle width can accommodate a la
number of channels in a given area, particularly if
advantage is taken of line-of-sight characteristics, anter
directivity, and frequency spacing. This band appear
be the most promising one for immediate use wher
small number of multiplexed channels is required.

1,850 to 1,990, 2,110 to 2,200, and 2,450 to 2,700 Megacy
The relatively greater width of these bands suits th
particularly well to systems using time-division or wide-b

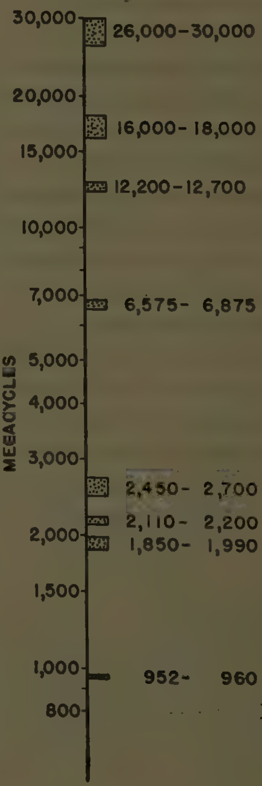

Figure 1. Commercial point-to-
(fixed operational) allocations in
microwave frequency spectrum

Essential text of paper **51-145**, "Application of Microwave Channels," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Southern District Meeting, Miami Beach, Fla., April 11–13, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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quency-division multiplexing methods, in which a large mber of channels per microwave frequency may be ed. Many of the advantages of the 952 to 960-megacycle nd are retained, although to a somewhat lesser degree. ibe efficiencies are lower, but disc-seal triodes have been veloped for several watts' output at frequencies up to 500 megacycles and may be used over most of these ree bands. Crystal-controlled transmitters do not appear sible because of the large number of multiplying stages quired, and frequency stability becomes an important sign and operating factor. Automatic frequency control ay be required in receivers, which offsets materially the ins in simplicity made by eliminating crystal control of e transmitters. Only short lengths of flexible coaxial ble can be used, and the rigid coaxial cable or waveguide quired for longer distances increases installation expense. alternative is to mount the transmitter proper close to e antenna, but this usually is undesirable from a main-nance standpoint. Smaller antennas can be used for a ven gain in these bands than for the 952 to 960-megacycle band, but large antennas may be required to provide equate margin for the more severe fading which can be pected in these bands.

In general, these bands appear best suited for trunk-line tallations where large numbers of individual voice-quency channels are required between two points.

6,575 to 6,875 Megacycles. In this band the use of klystrons magnetrons is practically required since disc-seal or hthouse types are not readily applicable. Enormous wer gains can be obtained with parabolas of relatively all diameter as compared with those for lower-frequency nds, but the rigidity required of the antenna mounting th the extremely sharp beams obtained is an important nsideration. Waveguides must be used between the nsmitter-receiver and the antenna unless the distance extremely short. Alternatively, the radiating antenna n be mounted near the ground and directed upward illuminate a 45-degree plane reflector at the tower p. However, this system also imposes severe require-ents with respect to rigidity of mounting. Attenuation e to rain, sleet, and snow becomes noticeable in this nd. For example, as shown by Figure 2, a cloudburst n cause an attenuation of 1.3 decibels per mile at 5 ntimeters (6,000 megacycles).[3] Offsetting this, however, the fact that rain of cloudburst proportions is not likely be encountered over an appreciable percentage of the tal length of a channel. Also, fading due to multipath opagation and other effects, for which some margin must provided in establishing the channel, is most severe ring calm atmospheric conditions.[4,5] Therefore, some the fading margin can be applied as a safety factor ainst rain attenuation.

SELECTION OF SITE

INCE MICROWAVE signals do not follow the curvature of the earth, as do signals in the lower-frequency radio nds, it is necessary to provide a line-of-sight path be-een the antennas, and, as an additional safety factor, path clearance of at least 50 feet from all obstructions ually is recommended. It has been reported by a number of observers that fading is considerably more severe when a grazing or near grazing path is provided than when some clearance is available. Over smooth spherical earth, the formula

$$h=\frac{S^2}{6}+50 \qquad (1)$$

gives with sufficient accuracy the antenna height in feet required at each terminal to give 50-foot clearance for a channel of length S miles. Table 1 shows typical antenna heights calculated from this formula for channels of various lengths.

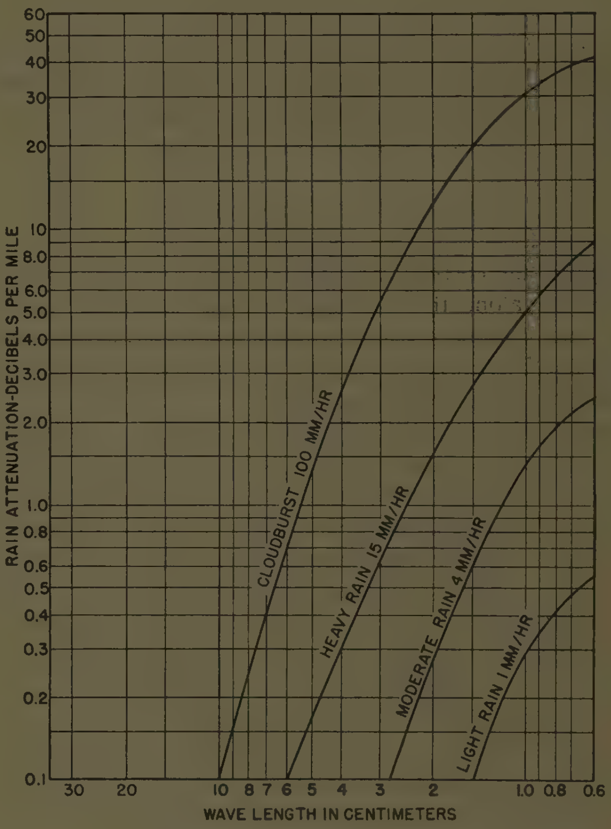


Figure 2. Rain attenuation as a function of wavelength

Table 1. Typical Antenna Heights

Distance in Miles	Antenna Height in Feet
5	54
10	67
15	87
20	116
30	199
40	314
50	462

In the practical case, however, smooth spherical earth is rarely encountered, and it usually is necessary to obtain topographical maps of the region in question and to make a profile drawing of the proposed route. The most convenient method of correcting such a drawing for earth curvature is probably to plot the profile directly from the

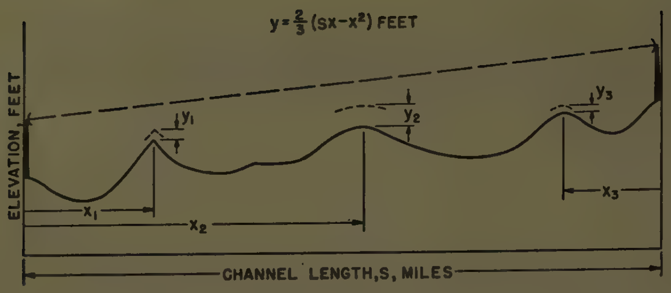


Figure 3. Method of correcting a profile map for earth curvature

topographical maps, without correcting for curvature, and then, as shown in Figure 3, to correct the height of the most prominent ridges or other obstructions by the equation

$$y=\frac{2}{3}(Sx-x^2) \tag{2}$$

where y is the correction in feet at a distance x miles from either end along the total path length S miles. If topographical maps are not available for the region in question, aerial navigation maps are sometimes obtainable, and these provide similar information.

Usually it is advisable to consider several alternate locations of the microwave terminals in an effort to find the one which requires the least antenna height. It sometimes will be more economical to locate a microwave terminal at some distance from the actual point of utilization of the transmitted intelligence, using leased or privately owned telephone pairs to carry the information from the microwave equipment to the utilization point, rather than to locate the terminals directly at that point.

In any case, after the sites are tentatively selected, it is advisable to survey the actual locations to make sure a line-of-sight really exists, since there may be some obstruction not shown on the topographical maps.

CALCULATION OF FREE-SPACE LOSS

MICROWAVE TRANSMITTERS and receivers are rated in terms of the maximum number of decibels of attenuation through which they will operate successfully. This rating is the total attenuation from the transmitter output terminals to the receiver input terminals, and its calculation must include the loss in coaxial cable at both terminals, if such cable is used, as well as the loss of energy in free space. The latter loss usually makes up by far the greater portion of the attenuation of a channel. The basic equation for the calculation of this loss is

$$\text{Free-space loss}=10\log_{10}\left(\frac{8\lambda}{\pi d^2}\right)^2 s^2 \text{ decibels} \tag{3}$$

in which λ, d, and s are the wavelength, the paraboloid diameter, and the channel length, respectively, all in the same units. An equation better suited for practical use is

$$\text{Free-space loss}=10\log_{10}\frac{1.745S^2}{f^2D^4}10^{14} \text{ decibels} \tag{4}$$

in which S is the distance in miles, f is the frequency in megacycles, and D is the antenna diameter in feet. The nomographic chart of Figure 4 solves this equation fo wide range of frequencies, channel lengths, and anten diameters. If reflectors of different diameters are used the sending and receiving ends, the equation becomes

$$\text{Free-space loss}=10\log_{10}\frac{1.745S^2}{f^2D_r^2D_t^2}10^{14} \text{ decibels}$$

The chart can be used for problems involving transmitt and receiving antennas of different diameters provid $\sqrt{D_r D_t}$ is used for antenna diameter in reading the scale

BEAM WIDTH

BEAM WIDTH is usually defined as the angle betw the half-power points of the beam, that is, the an between the two coplanar lines along which the ener density is half that along the axis of the parabola at same distance. In terms of wavelength and the diame of the paraboloid the beam width is given theoretically b

$$\theta=\lambda/D \text{ radians}$$

or

$$\theta=57.3\ \lambda/D \text{ degrees}$$

In practical cases, due to uneven illumination of the

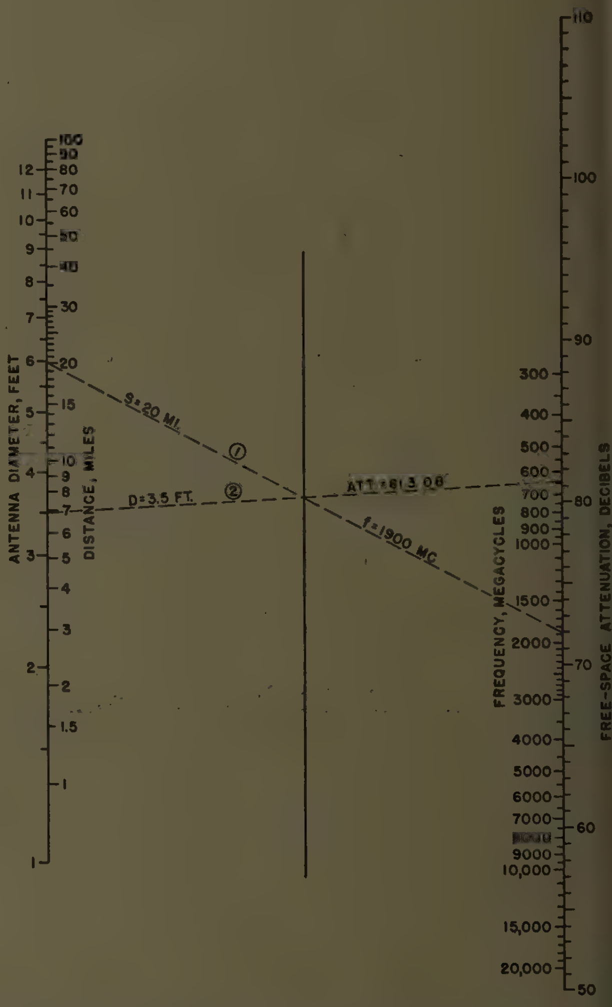
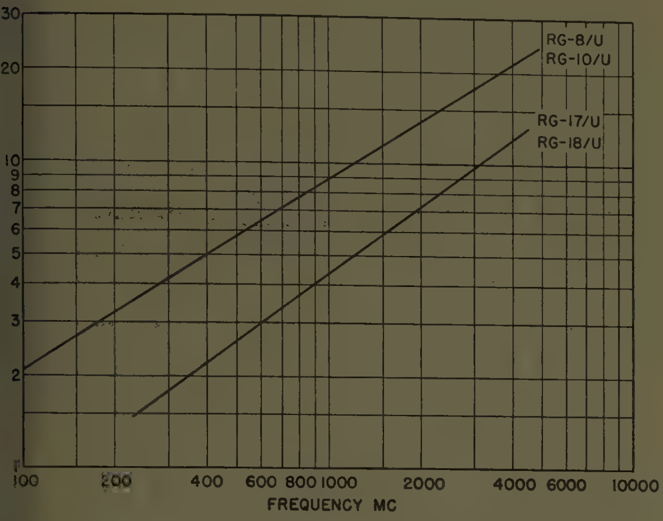


Figure 4. Nomographic chart for calculation of free-space as a function of distance, frequency, and antenna diameter. a straight edge on chart between distance and frequency. E point of intersection with auxiliary line, revolve straight edg antenna diameter, and read free-space loss on right-hand s

ector by the dipole, the actual beam width is about per cent greater, or

$$=70\,\lambda/D \text{ degrees} \qquad (8)$$

extremely narrow beams are used, the deflection of the ntenna supports as a result of wind loading should be



igure 5. Losses in RG-8/U, RG-10/U, RG-17/U, and RG-18/U coaxial cable as a function of frequency

ecked carefully to make certain that the aiming of the ntennas remains correct within half of the beam width nder any wind conditions likely to be encountered. aximum deflection at both ends then will result in a loss 6 decibels' total, but since deep fading is not likely to ccur under turbulent atmospheric conditions, it should ot be necessary to include this loss in estimating the aximum attenuation of the channel.

COAXIAL CABLE LOSS

THE LOSSES in type *RG-8/U* and *RG-17/U* cable at frequencies in the microwave region are shown in igure 5. Losses in the corresponding armored types, *G-10/U* and *RG-18/U*, respectively, are the same. An pproximate equation for estimating the attenuation of r or gas-filled coaxial cable is

$$\text{ttenuation}=0.026\sqrt{f}/D \text{ decibels per 100 feet} \qquad (9)$$

here D is the inside diameter of the outer conductor in ches and f is frequency in megacycles. The attenuation rectangular waveguide at a frequency approximately 2 times the cutoff frequency can be estimated by the rmula

$$\text{tenuation}=0.04\sqrt{f}/b \text{ decibels per 100 feet} \qquad (10)$$

here b is the width of the guide in inches. More complete rmulas can be found in references 7 and 8.

FADING LOSS

SOME ALLOWANCE must be made for fading of the signals from free-space values. Experience at 960 mega- cles indicates that an allowance of one-half decibel per mile for fading is conservative for a path with 50-foot clearance.[6] Available data on propagation at higher frequencies indicate that an allowance of one decibel per mile should be made at 2,000 and 6,500 megacycles.[4,5] The calculation of the maximum probable attenuation should include this allowance in addition to the free-space loss and the terminal losses at each end.

CALCULATION OF LOSSES OF A 960-MEGACYCLE CHANNEL

THE CONSIDERATIONS just discussed will be applied in the calculation of the total attenuation of a typical 960-megacycle channel. The channel is 32 miles long, and the terrain requires antenna elevations of 200 feet at each end. From Figure 4, the free-space loss with 42-inch paraboloids at each end is 91.1 decibels. The loss in 400 feet of *RG-17/U* cable (200 feet at each end) is 17 decibels. Including a fading allowance of 0.5 decibel per mile, or 16 decibels, the total attenuation of this channel is 124.1 decibels under maximum fading conditions. This is within the 125-decibel rating of a typical microwave transmitter-receiver for this band. The use of *RG-8/U* cable would have resulted in attenuation in excess of this rating. An alternative would be to use *RG-8/U* cable with parabolas of larger size, but in general it is more economical to use the larger cable rather than to increase the antenna size, where the necessary reduction in loss can be accomplished in this manner:

$$\text{Free-space loss} = 10\log_{10}\left(\frac{4\lambda s}{\pi D^2}\right)^2 \text{ decibels} \qquad (7)$$

This is an approximation which still does not take into account the effective area of the reflectors, as compared with the physical area. The effective area depends upon the design of the paraboloid and the location of the dipole and may vary from 0.5 to 0.8 times the physical area. If, in order to be conservative, we use a figure of 0.5 for the ratio of effective area to physical area, then equation 7 must be modified to take this factor into account at both ends of the system. Equation 7 then becomes

$$\text{Free-space loss} = 10\log_{10}\left(\frac{8\lambda s}{\pi D^2}\right)^2 \text{ decibels} \qquad (8)$$

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New Electrodes for Inert-Gas Welding Arcs

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WITH THE increased use of inert-gas arc welding, especially in automatic welding machines, problems of arc ignition and stability become important. New electrodes much more satisfactory than the conventional type have been developed by using the highly refractory oxides, thoria and zirconia, in combination with tungsten and other materials. The conventional welding electrode is of some nonconsumable material, usually tungsten, and starting is accomplished either by contact or by a high-frequency spark. When spark starting is used, ignition may be quite erratic, depending on the previous history of the tungsten electrode. If the electrode is cold, the arc may not form immediately or at all, and, when formed, it may be extremely mobile, with the footpoint moving rapidly over the tungsten surface. In an automatic setup, this type of behavior can lead to losses in both time and material. See Figure 1. This shows the effect on the work of slow starting and arc wander. Also, the welding torch may be damaged.

With the new electrode, instant starting and a highly stable arc are obtained. The arc picks up at lower open-circuit voltage and the current ranges are extended.

In straight polarity inert-gas arc welding, the tungsten electrode may serve as either a thermionic[1] or a "cold"[2,3] type of cathode, depending on operating conditions. When starting is attempted with a cold electrode, evidently an arc cathode spot cannot be established unless there is some oxide present. If the arc does start, there are two possibl conditions, depending on the amount of oxide present an on the electrode current density. If there is sufficient oxide the cathode spot will stay on the tip and, if the current i great enough, the cathode will become a thermionic emitte as its temperature rises. If there is not enough oxide, th cathode spot will quickly clean the surface at the spot, the wander to new oxide-bearing regions. Since the new electrodes contain an adequate supply of highly refractor oxide, these effects are not present. Both the zirconia an thoria can be used as coating on tungsten, or they can b used as cores in other metals. In addition, thoria powder ca be mixed with tungsten powder to give a sintered electrode

The open-circuit voltage required for starting with a high frequency spark in argon is about 190 volts for pure tungsten, whereas for zirconia-tungsten it is only 40 volts an for thoria-tungsten only 25 volts. The current range for 3/32-inch-diameter electrode is about 140 to 280 ampere for tungsten[4] and 6 to 375 amperes for thoria-tungsten For zirconia-tungsten, the range is somewhat less.

The cathode current density was investigated by photographing the cathode spot on the electrodes (Figure 2 Apparently the thoria-tungsten material acts as a low wor function thermionic emitter operating at a temperature below that observed for pure tungsten. The emission process for the zirconia-tungsten electrodes takes place at higher current density than accounted for by thermionic emission

The material consumption rate fo electrodes is less than for tungsten When used in helium, slightly highe rates of loss are observed, due to increased heating, and possibly t less efficient repression of cathod evaporation by the lighter heliu atom.

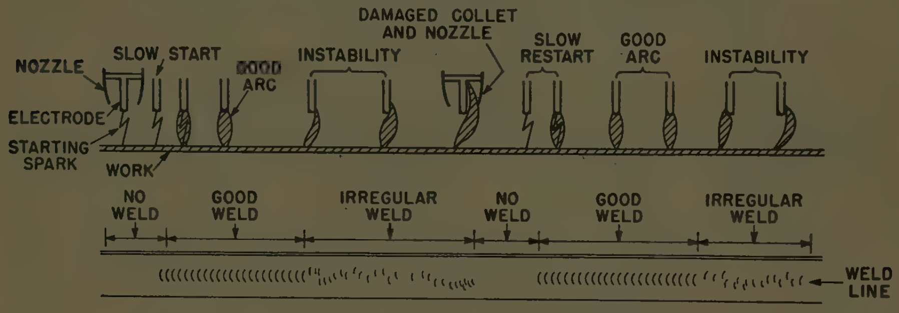

Figure 1. Normal tungsten electrode used in inert-gas arc welding

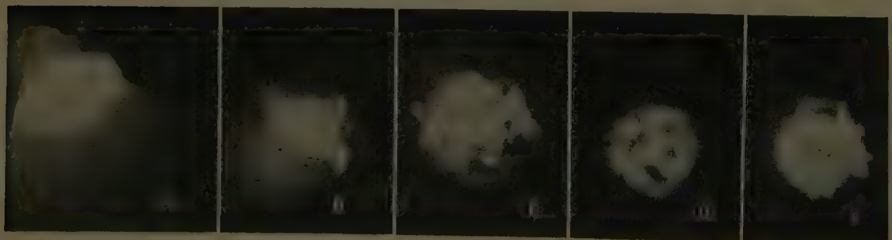

Figure 2. Cathode spots on $^1/_8$-inch-diameter electrodes. (A) pure tungsten; (B) zirconia-coated tungsten; (C) thoria core in sintered tungsten tube; (D) thoria core in copper tube; (E) sintered tungsten thoria electrode

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A 2,000,000-Kva Transformer Core

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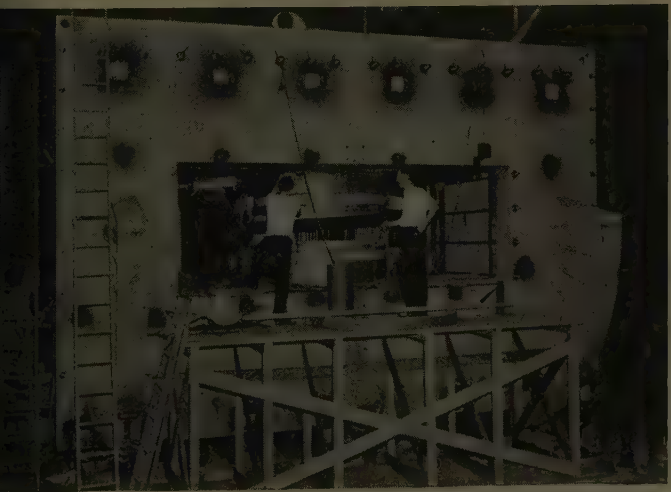
THE LARGEST 60-cycle transformer core ever made is now in successful operation on a 300,000,000-volt etatron at the University of Illinois. If this core were sed for an oil-immersed power transformer, windings for ontinuous operation at 2,000,000 kva could be placed on t. Construction of this core demonstrates the feasibility f constructing transformers many times as large as have een built to take advantage of lower cost per kilovolt mpere and increased efficiency. Cores several times as arge as this one can be made employing similar construcion. Shipping clearances limit the size and weight of ransformers which can be assembled in a factory and hipped to their destination. These limitations can be emoved by assembling transformers in the field.

This core was designed by power transformer engineers nd assembled in the field under the supervision of transormer erection engineers. Since the core operates at 60 ycles, the mechanical and electrical construction used is ypical of the construction required for 60-cycle power ransformer cores of the same physical size. The betatron s a high-voltage transformer in which the primary winding s a wound transformer core and the secondary winding s a stream of electrons going around in a circle inside of a oughnut-shaped porcelain vacuum tube.

The main core of the 300,000,000-volt betatron is a shellype transformer core made of 0.014-inch-thick silicon teel of transformer grade with a stack height of 75 inches, length of 280 inches, and a height of 154 inches. Including the end frames the dimensions are 287 inches long y 196 inches wide by 212 inches high. The total weight f transformer steel in the core is 575,000 pounds. The lanes of the laminations are vertical, in which position hey are self-supporting, and construction is similar to that sed for large power transformers with circular coils.



igure 1. The 300,000,000-volt betatron being erected in the University of Illinois Physics Laboratory

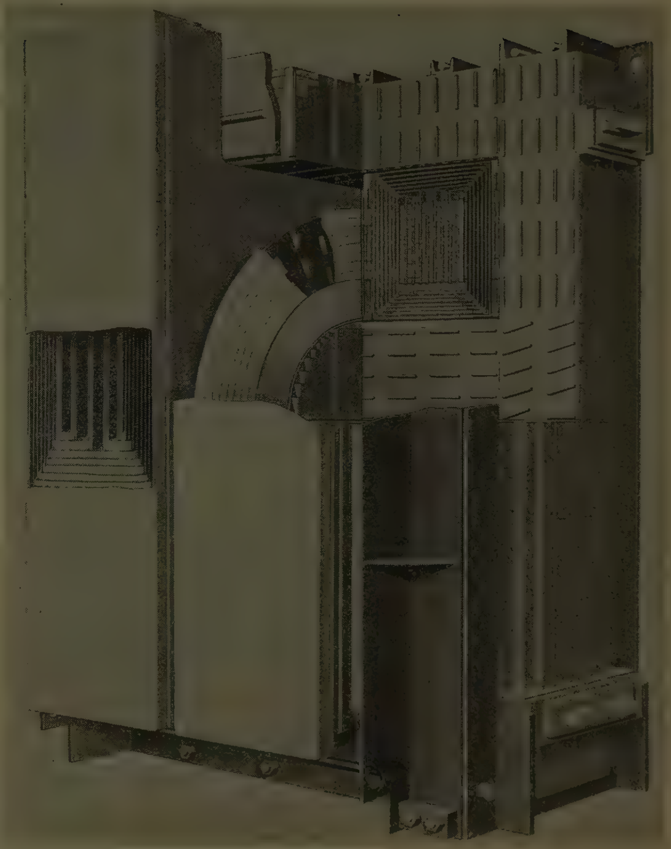


Figure 2. Typical core and coil construction for a 2,000,000-kva power transformer

The steel of the core is clamped between steel end frames which hold the core in position and provide a mounting for the auxiliary cores of the betatron similar to the mounting which would be necessary for clamping the coils of a power transformer. By the use of a combination of tie bolts and jack bolts, the necessity for bolts through the core iron with their accompanying hazards is avoided.

Designs of power transformers to fit in this core have been laid out varying from 2,100,000 kva at 15 kv to 1,200,000 kva for a 230-kv transformer. The coils for such transformers should be circular discs which provide maximum strength of the winding for assembly and to resist short-circuit stresses.

Although the cost of field erection on a per-pound basis of material is greater than that of factory construction, the saving in weight and improvement in efficiency inherent in a larger unit may at a future date make construction of larger and heavier transformers an economical procedure.

Digest of paper **51-2**, "A 2,000,000-Kva Transformer Core," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Equivalent Circuits of the Shaded-Pole Motor

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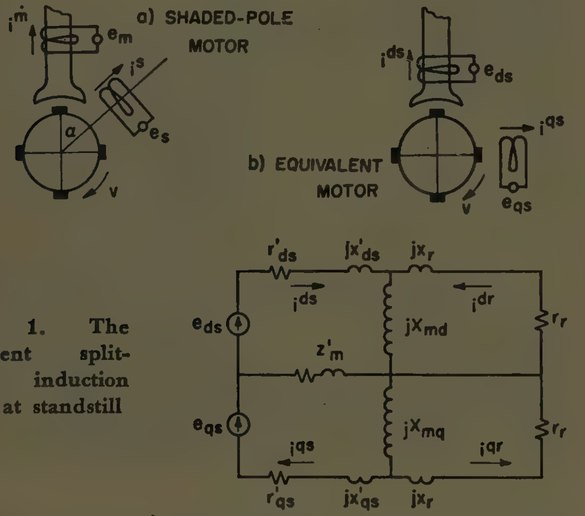
EQUATIONS AND equivalent circuits are developed for the shaded-pole motor, including the space-harmonics introduced by the stator windings. Uneven air gap, also excitation on the shaded pole, are assumed, while the parameters include the angle of shift and the ratio of turns. The equations and equivalent circuits cover both the cross-field and the revolving-field theories.

The shaded-pole motor, or a split-phase induction motor with one of its stator windings shifted by an angle α (Figure 1A), is considered here as a standard type of split-phase induction motor with its two stator windings at right angles



c) REACTANCES OF THE EQUIVALENT MOTOR

$e_{ds} = e_m$

$e_{qs} = \frac{e_s}{a \text{ SIN } \alpha} - e_m \text{ COT } \alpha$

$i^m = i^{ds} - i^{qs} \text{ COT } \alpha$

$i^s = \frac{i^{qs}}{a \text{ SIN } \alpha}$

$r'_{ds} = r_{ds2}(1 - \text{COT } \alpha)$

$x'_{ds} = x_{ds2}(1 - \text{COT } \alpha) + x_{dsm}$

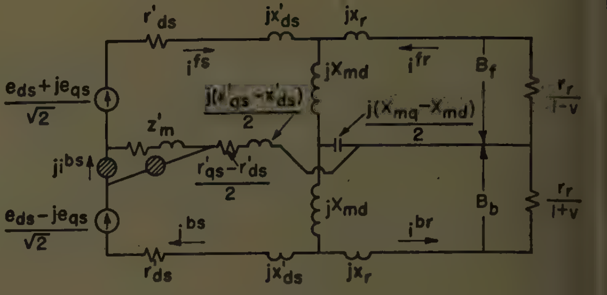
$r'_{qs} = r_{qs1} + r_{ds1} \text{ COT}^2 \alpha + r_{ds2} \text{ COT } \alpha (\text{COT } \alpha - 1)$

$x'_{qs} = x_{qs1} + x_{ds1} \text{ COT}^2 \alpha + x_{ds2} \text{ COT } \alpha (\text{COT } \alpha - 1)$

$z'_m = (r_{ds2} + jx_{ds2}) \text{ COT } \alpha$

d) RELATIONS BETWEEN ACTUAL AND EQUIVALENT MOTOR

Figure 1. The equivalent split-phase induction motor at standstill



TORQUE=REAL OF $i^{fr}B_f^* + i^{br}B_b^*$

Figure 3. Equivalent circuit of the shaded-pole motor (revol ing-field theory)

in space (Figure 1B) and having three additional complic tions: (1) a mutual impedance z_m' appears between its tw stator windings at right angles (Figure 1C); (2) its air ga is nonuniform ($X_{md} + X_{mq}$); and (3) large space ha monics are produced by the stator windings, that rea upon the squirrel-cage rotor (Figure 2).

The design constants are calculated by assuming th shaded pole to lie first along the axis of the main windin then at right angles to it. When the shaded pole lies at a angle α in the direction of rotation from the main windin its reactances (primed quantities) are found from the ca culated reactances (unprimed quantities) by the relatio of Figure 1D. It should be noted that the rotor and a gap design constants are not changed by the angle of shi

The resultant equivalent circuits, both the revolvi field (Figure 3) and the cross-field circuits, including t space-harmonics (Figure 2) or without them, are the sar as those of a standard split-phase induction motor having a uneven air gap. The effect of mutual reactance betwe stator windings is to introduce a phase-shifter to rota the currents and voltages of one of the meshes by 90 degre

Digest of paper 50-117, "Equivalent Circuits of the Shaded-Pole Motor with Sp Harmonics," recommended by the AIEE Committee on Rotating Machinery approved by the AIEE Technical Program Committee for presentation at the AI North Eastern District Meeting, Providence, R. I., April 26–28, 1950. Published AIEE *Transactions*, volume 69, part II, 1950, pages 735–41.

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TORQUE=REAL OF $i^{fr}B_f^* + i^{br}B_b^*$ $k_n = \frac{k^2_{(n)}}{k^2_{(1)}}$

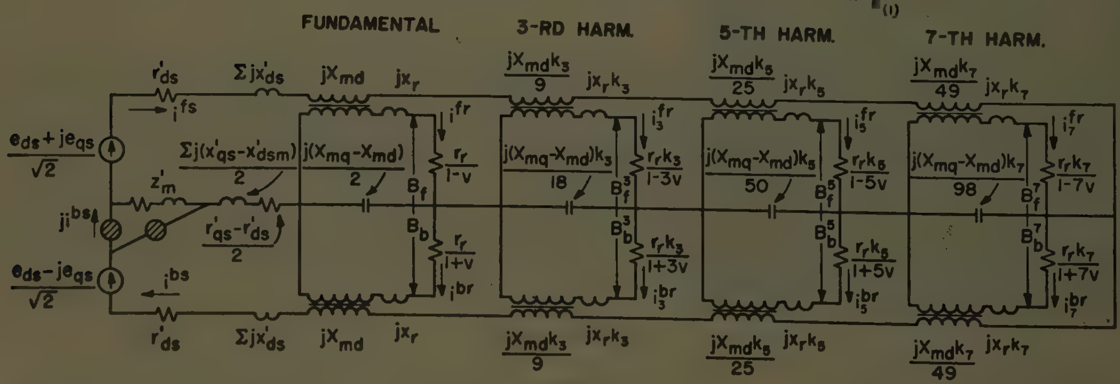

Figure 2. Equival circuit of the shad pole motor includi space harmonics (volving-field theo

Mathematics in Electrical Graduate Education

E. W. ANDERSON

FOR A NUMBER of years I have been concerned with a study of the course content and the teaching of engineering mathematics. As a result of this long con-nued interest in that gray area between the two extremes f pure and applied science, I am firmly convinced that ducation ought to be useful. To make such a statement nay, at first, seem unnecessary. However, I use the term iseful' in a broad sense and with connotations that I will y to define more clearly later.

First, if graduate education is to be useful, it must satisfy ne needs of the student. Some of these needs will be ap-arent to him; many, because of his immaturity and lack f experience, will not. A great many of his needs will be ndividual in character, directed toward preparing him or his ultimate professional and civic duties. It is a matter f obligation of the faculty to see that all these needs re-eive some attention.

At this point I wish to put in a plea that we think of raduate training, particularly at the doctorate level, as eing an individual matter. ollowing the last war, our raduate schools had the two-old problem of a large in-ux of graduate students and dearth of trained staff. This esulted in a tendency to treat raduate education as a mass ducation procedure. Such n attitude seems to me to be nost regrettable, particularly with regard to the mathemat-cal aspects of the education of the electrical engineer.

The mathematical training of an engineering student should be designed to meet his current and future needs. College faculties should consider carefully the needs which are common to all and should stress the importance of application in the teaching of general courses.

GENERAL NEEDS

IN ORDER to achieve the goal of useful education, it is neither necessary nor desirable to cast all our engineer-ng students in the same mathematical mold. The world as need for electrical engineers with widely divergent types f training. Hence, if we first admit the ubiquity of math-matics throughout the engineering field and the close elationship between mathematics and electrical engineer-ng, there is still a great demand for engineers without the ery latest and topmost tools and theories that mathematics as to offer. Encourage the man who has a particular bent oward mathematics and who seems to show ability to anslate his mathematical training into active use to take ll the mathematics that time and a balanced program ermit. But, in general, it is better to try to meet individual eeds by matching the program with a student's abilities nd interests. Not only does the mediocre or uninterested udent of mathematics act as a drag on the rest of the class but, in addition, he is probably spending an excessive amount of time on preparation, time which might be better spent elsewhere.

While I am firmly convinced of the desirability of the approach to graduate training which takes into account individual needs, critical investigation shows that there are certain broad general needs which are common to all graduate and also undergraduate students. Far too little faculty consideration is given to these. Even where the needs are well known and defined, it is quite common to pay little attention to the pedagogical procedure by means of which they are supposed to be satisfied.

CURRENT AND FUTURE NEEDS

A GRADUATE STUDENT must have the mathematical concepts and abilities necessary for doing the current course work. In addition, he must be able to read a certain portion of the periodical literature in his field both in the present and in the future. An electrical engineering faculty needs to be considering these matters constantly. A study of current needs is not particularly difficult.

Every year in my classes of advanced mathematics for engineers I ask each student to examine critically the articles in one or more of the current volumes of the periodical literature of his field. By distributing the various journals with some care and by asking the students to list the frequency of occurrence of various mathematical topics and techniques, one can get a good picture of the mathematics in use today. This procedure serves a triple purpose. First of all, it provides me with a rich source of problem material. In the second place, it provides motivation. That is, from the teacher's standpoint, after a student has noted the high frequency of occurrence of such items as boundary value problems involving ordinary and partial differential equations, Bessel functions, vectors and tensors, hyperbolic functions, infinite and Fourier series, complex variables, numerical and graphical solutions of equations and differential equations, gamma and beta functions, elliptic integrals, dimensional analysis, Laplace and Heaviside operations, matrices, and statistical and probability procedures, the problem of motivation has disappeared. In the third place, the frequency study just described offers a great help in

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Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Recommended by the Committee on Education.

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determining which and how much of each of the topics should be included in the general training program.

Table I shows the frequency chart with the number of articles of a given volume in which an itemized topic occurs at least once. These data were collected by graduate students who were not yet thoroughly familiar with all the items under investigation. Hence, the results must not be considered as completely reliable. Nevertheless they give a general indication of the frequency of use of the various topics.

Then comes the more difficult task of predicting the future. Where is electrical engineering going? Where will it be ten years from now? How much training should we give? It is an established fact that the "higher mathematics" of yesterday becomes the "ordinary mathematics" of today. If you do not believe this, compare your own training with the training we are offering now. Think of the mathematical knowledge we are requiring of our present engineers and compare it with that required 20, 30, and 40 years ago. At the turn of the century, h many electrical engineers were familiar with the theory elementary differential equations, with complex numbe with Fourier series?

It seems to me that because of the extremely dynan nature of the field, an electrical engineering faculty oug to give frequent consideration to these matters and sho determine by committees or otherwise and with the help advice from alumni and industry and in conference w the members of the mathematics staff directly concern the general mathematical training to be given to all selected groups of its students. Such matters of importar should not be left entirely to the service department. I usually true that provided with a definition of ends, mathematician is probably well prepared to supply means to the end and often may be safely left to himself this score.

Table I. Frequency Chart

Data Collected by Students of an Advanced Engineering Mathematics Class

Periodical Surveyed	Number of Articles Examined	Number of Articles in Which Topic Occurs																																
		Diff. Equations																																
		Ordinary				Partial																												
		Linear	Vibrat., Non-Lin.	Other		Linear	Other		Fourier Series	Infinite Series	Bessel Functions	Gamma Functions	Legendre Functions	Vectors	Tensors	Matrix Theory	Probability	Statistics	Curve Fitting	Graphical Solutions	Numerical Solutions	Complex Variables	Contour Integrat.	Conformal Transf.	Other	Operat. Calculus	Laplace	Heaviside	Other	Integral Equations	Fresnel Integrals	Line Integrals	Sine, Cos Integrals	Calcul. of Variat's.
Proceedings, Institute of Radio Engineers, vol. 38, 1950	80	23	2			16			8	17	8	5		8		3		1	1	4	26		3	2	32		7	1	6		1		1	
Bell System Technical Journal, vol. 29, 1950	20	1		3		2	10		5	3	2	1	1	5	1	2	1								2		1			1			1	
Electrical Engineering, vol. 69, 1950	24	9	1			1	1		1	3				4		2	1	2	1	2	1						1	1		8				
Proceedings, Institution of Electrical Engineers (British), vol. 96, 1949	116	13	1	2		5	3		3	10	4	1		7					1	3					1		3		1	10	2			
Electronics, vol. 23, 1950	120	2							2	2							1													2			1	
Physical Review, vol. 76, 1949	120	8		31			43			8		1		27	12	10	3	1					6		2		1		1	8			3	10
Zeitschrift fur Physik, band 125, 126, 1949	68	4	1	9		2	10			11	4	1		6	2		1				2		2		3		2		1	10		1	2	2
Journal of Applied Physics, July—Dec., vol. 20, 1949	151	21	8	3		13	9		16	16	22	3	5	29	10	7	6	3	1	3	5		1	1	5		13	1	4	10	3	3	2	3
Reviews of Modern Physics, Jan.—June, vol. 21, 1949	67	10	2			4	3		5	7	1	2		5	9	9	5	1	1	2							1			4		1	1	
Trans., American Geophysical Union, vol. 30, 1949	77	5	2			11			2	1	2			3			2	8		3	3				1					5		1		
Journal of Aeronautical Science, vol. 17, 1950	74	41	10	3		24	6		6	6	8		2	4	1	5				3	11		4	4	5		6	1		21	1	4	7	3

IMPORTANCE OF TEACHING METHODS

HOWEVER, his training and pedagogical methods may have a great deal to do with the usefulness of the par- ular facet of education which he provides. It is my be- f that mathematics courses for the technological student ould be taught with an attitude sympathetic toward ir application. I emphasize this with a statement made A. N. Whitehead in addressing a British mathematical ciety many years ago: "Education is the acquisition of e art of the utilization of knowledge." This quotation plies that the ability to utilize knowledge is as important the knowledge itself; that it is not sufficient to acquire concept or theory. In addition, the student must be able use it. Thus, and here I am speaking about courses m the freshman level on up, the instructor frequently ould tie the mathematics to physical situations in lecture d discussion and should give the student opportunities to e his theory in the study of simple but realistic problems. this regard, however, it is obvious that an instructor can- t spend a great deal of time on applications if he hopes to mplete the theoretical requirements of an already over- rdened curriculum, but, by merely indicating the use a certain topic and by his general sympathy toward plied work, he can increase tremendously the interest of s students.

I know that it is quite possible to teach mathematics in rms of x and y, A and B, and so forth, with no reference to ssible use. For certain types of minds this may be satis- ctory. However, I believe that the ordinary engineering dent is apt to minimize the importance of materials that e presented in this fashion. He tends to feel that the aterial can be left in peace in that special cubicle reserved things of little practical importance. Then a year or later he comes up with an apparent lack of mathematical ining and complains that the mathematicians have fallen wn on the job again.

Hence, I believe that it is extremely important that athematics courses intended primarily for engineering dents be taught by people who have definite physical terests and who are able and willing, from time to time, to low through the whole routine of the scientific method as applies to the solution of physical problems. This is im- rtant at the undergraduate level and is probably just as portant at the graduate level, especially in those courses hich are in the general-needs category.

A personal experience will illustrate this point. It con- rned a course in complex variables. The instructor had excellent grasp of the theory but not the slightest interest its use. We were given a wonderful experience in mathe- atical rigor, but many of the most useful parts of the sub- t, those which related particularly to physical applica- ns, were either neglected completely or given but a ssing mention. The invariance of Laplace's equation and rtain types of boundary conditions under a conformal nsformation was never suggested. Our attention was t focused upon the most useful types of contour integra- n. Instead we were concerned with pathological cases. admission that there were applications would have been desecration of an art. It was not until several years later at I realized how much had been left out of the course. From my own standpoint, that of the applied mathematician, I felt that I had been cheated.

THE PLACE OF PURE MATHEMATICS

IN THE PRECEDING statements I may seem to have minimized the importance of pure mathematics and the pure mathematician. Such was not my intention. Mathematics is a field with "a glorious past and a dynamic present." The pursuit of knowledge for knowledge's sake does not need justification from me. Mathematical ideas and theories developed purely for reasons of intellectual curiosity again and again have been picked up by the right man and used to explain physical phenomena. One example is the use of the complex number to explain the behavior of the alternating current.

Because of this possibility of the utilization of theory to explain physical phenomena, it is important that some of our mathematically inclined electrical engineers be given every opportunity to delve into the more intricate and abstract phases of mathematics. Amongst them may be a Steinmetz.

Then, too, as a general rule the easier theoretical research problems have been solved. The solution of those remaining seems to require ever more extensive mathematical knowledge. However, it may be best to look to the consulting specialist in mathematics in solving problems of this type.

At this point I wish to indicate again that "higher mathematics" is a temporal term which, as was so ably said by T.C. Fry, "means simply those branches of mathematics which have not yet found a wide field of application." Also I wish to make the prediction that in the future, considering such things as Shannon's work in the field of communications and the amount and type of electrical research now being pursued, far more training in statistics will become a necessity. Also I believe that we may look for even more need for Laplace and other transforms, matrix and tensor theory, complex variables, and nonlinear differential equations.

The general-needs type of course was mentioned earlier in this article. At that time I suggested that the electrical engineering faculty, either as a whole or through committees, should be continually studying the changing mathematical needs of its students and then attempting to see that these needs are fulfilled. Naturally, in a good many schools there will not be a sufficiently large number of graduate or combined graduate and capable senior students to justify the offering of such a course for them alone. Hence, a compromise has to be effected, and they must be enrolled in a course with engineers from other fields. This situation is not too serious. Examination of the texts and more theoretical periodical literature in the various engineering branches shows that there is a great deal of similarity in the mathematical subject matter in general use. Perhaps the electrical literature is more closely allied to the aeronautical than to that of the other fields, but no great differences between the literature of the various fields of engineering seem to be prevalent.

Boundary value problems involving differential or integral equations subject to secondary conditions are common to all fields. At some point in his career the student needs to be thoroughly grounded in the philosophy and procedure of boundary value problem solution. It would seem that, in the general sense, no student should escape without knowing the roles played by eigen or characteristic values, the differences in technique distinguishing the attack on problems involving ordinary and partial differential equations (complete versus particular solutions), something about complete function systems, something about the advantages connected with picking the right co-ordinate system in which to frame the problem, and so forth.

Of course the twin questions—how many of the tools commonly employed in solving boundary value problems are to be presented and how sharp each of these tools is to be made—must depend necessarily on the amount of time available and the needs of the individual institution.

One interesting thing about the tools in this category such as Bessel functions, Fourier series, and so forth, is that while they provide effective aids for solving boundary value problems, they are also included among the more commonly used topics needed in the regular course work. Thus, while they can be studied as unrelated topics, they all can be neatly tied together in connection with the study of boundary value problems.

THE LEARNING PROCESS

ONE subject that is mentioned with some hesitancy concerns repetition and the learning process. At Iowa State College a student has his first exposure to the concept of moment of inertia in physics. The next contact comes in calculus. Then he meets moment of inertia in statics. Yet after three exposures he frequently enters the courses of dynamics and strength of materials with but a vague notion of the true meaning of moment of inertia. Similarly, many of the mathematical topics and concepts appear very foreign and difficult to him when he first encounters them. Hence, in order that the student become sufficiently skilled in their use, it may be advisable to allow him several contacts with some of them. For example, it may be desirable to repeat at the graduate level with less superficial treatment some of the topics studied earlier, perhaps during the junior year.

SCIENTIFIC METHOD

I WISH TO return once again to something I mentioned earlier. This is a method of problem solution which has been given various titles but which I called the scientific method. When speaking of it, I was thinking of the method as it applies to problems of a particular type; for example, those which yield to mathematical treatment. However, some of what I have to say applies equally well if the solution requires logical analyses or experimental techniques.

Streamlined, the method may be thought to consist of three major parts. The first is concerned with the collection of data pertinent to the problem, the determination of the laws or principles needed for the solution, and the translation of these laws into mathematical form. The second is concerned with the grinding of the mathematical mill, a process necessary to effect a solution. The third is concerned with the interpretation of the results.

As a rule and with few exceptions, mathematics courses deal with tools which can be employed in connection with the second part or operation of the mill. Even many o the courses which purport to deal with physical problems merely follow through processes developed in an earlier era by someone other than the student. They are historical in character. Yet, if the education of the student is to be made as useful as possible, if he is to develop the ability to solve realistic problems for himself, he needs the experience o going through the whole procedure not once but again and again.

It takes long training and practice to develop the judgment needed to sift out the less important factors of a problem and to develop the ability to make reasonable simplifying assumptions and approximations which wil establish a practical mathematical ideal; for example, a mathematical formulation which will offer some chance fo solution without impairing the results.

In all fairness it should be admitted that all problems involve the elements of the scientific method to some exten and, further, that efforts are made to provide the studen with complete experiences in its use. For example, a Iowa State, as in many other institutions, we have one terminal undergraduate electrical engineering problems course which attempts to do this. The course was put on a firm initial footing by the originators and it has been continued along the lines originally charted. A series of problems has been developed which lead the solution-seeking student into almost all of the areas of knowledge which h has previously met and into many of whose existence h did not even dream.

However, we do too little of this sort of thing. We fin the idea good at the undergraduate level, then drop it a the graduate level. As a rule the graduate courses are highly specialized and the problems are designed to fit the specialty. It seems to me that it might be well to give serious thought to the idea of including more of these broader types of electrical engineering problems courses in our graduate curriculum.

SUMMARY

IN SUMMARY then, mathematics plays an important role in the education of the graduate student. In order to be most valuable, a student's mathematical training should be tailored to his individual needs—both in the immediat and long-term sense. Since a large number of his needs are common to those of his fellow students, these commo needs probably can be economically satisfied by a set o general courses covering carefully selected mathematica topics. As a rule, these and other mathematics courses fo the engineering student become more useful if taught b instructors who are trained in, or are at least sympatheti toward, the field of applications.

The content of the general set of courses should be determined through joint agreement of representatives of th electrical engineering and service departments after carefu consideration of the present and future needs of the studen Faculty, student, industrial, and alumni opinion, as well a studies of current text and periodical literature, will aid i determining the course content.

Fuses for Resistance Welding Machines

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CHARACTERISTICS of fuses generally are given by curves in which overload current is plotted against he time required to blow the fuse. This relationship is ecessary for most applications, but where the fuses are alled upon to protect a device which is recurringly overoaded and unloaded, the characteristics are not useful. xamples of a recurring load exist in the resistance welding ield where the welding machine draws up to four to five imes its thermal rating during the welding period. Rating heets for welders and ignitron tubes used with welders an best be expressed in terms of current and duty cycle. ince the welding industry is acquainted with rating sheets f this type, it is desirable to have rating sheets for fuses sed in this industry expressed in the same terms.

In order to prepare a current-duty cycle curve, all availble data were obtained from nine major fuse manuacturers. Information was requested on the current equired to blow 250- and 600-volt fuses when the current uration was 0.1 to 1.0 second. This is the time range in hich most resistance welding machines are operated. Of he nine fuse manufacturers contacted, only four had data n the current required to blow fuses at very short times. f these four, two had only partial information. The alues that were obtained were widely scattered.

Since the available data were extremely meager and ince an examination of data revealed no consistency from anufacturer to manufacturer, it became apparent that no niversally acceptable current-duty cycle curve could be made.

Since one curve is impossible to construct, a model eating-cooling system can be mathematically developed hich will enable a user to take available fuse characeristics and make his own curves. From this model ystem it can be shown that

$$I_0=I(\mathrm{DC})^{1/A} \qquad (1)$$

here I_0 is the current at which a fuse will blow at an nfinite time; I is the overload current passing through the use during the weld; DC is the duty cycle, and A is a eating constant. It can be calculated as follows:

$$A=\frac{\log t_2/t_1}{\log I_1/I_2} \qquad (2)$$

here t_1 and t_2 are two short "times" to blow corresponding o the currents I_1 and I_2.

In order to complete the necessary curve, the averaging ime (t_c') of the fuse must be determined. It can be calulated as follows:

$$t_c=t_1(I_1/I_0)^A \qquad (3)$$

By use of these formulas, a curve similar to Figure 1 can e made. In order to check the curve with actual fuse ractice, data were gathered on demand current versus fuse rating for both spot and seam welding. On seam welders, a 100-ampere fuse is used between 170 and 230 amperes. Checking this figure against Figure 1, it can be seen that the allowable duty cycle for a 100-ampere fuse operated at this demand is between 45 and 80 per cent. This is approximately the duty cycle at which seam welders operate. The 100-ampere fuse is used between 475 and 625 amperes for spot welders. Checking this against Figure 1, it can be seen that the duty cycle can be between four, five, and eight per cent. This is the duty cycle at which spot welders operate.

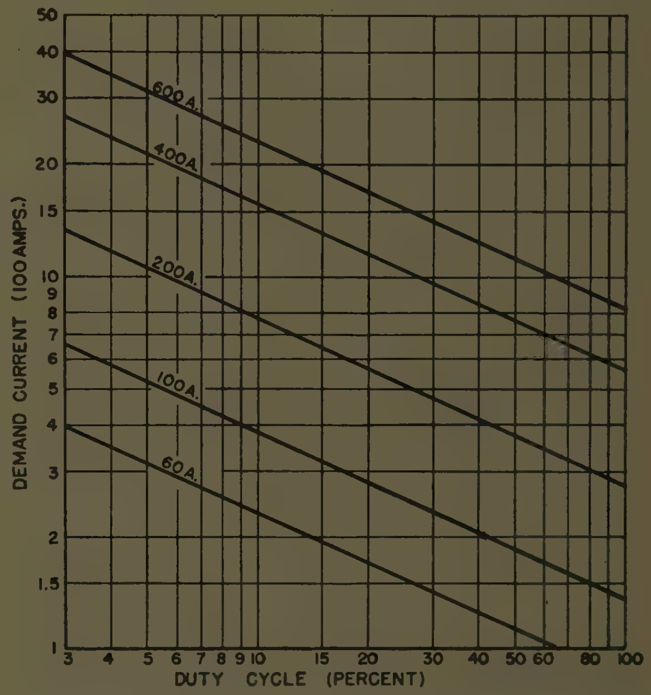

Figure 1. Demand current versus duty cycle for A=2.2

CONCLUSIONS

1. Fuse characteristics are not standardized; therefore, it is impossible to make specific recommendations on the applications of fuses to resistance welding machines.
2. A method has been proposed whereby it is possible to take the fuse characteristics of a given manufacturer and develop the necessary curve to be able to apply the fuses to an intermittent load intelligently.
3. It has been shown that the results when using the proposed method compare favorably with actual practice.

Digest of paper 51-141, "Selection of Fuses for Resistance Welding Machines," recommended by the AIEE Committee on Electric Welding and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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A Study of the Economics of Power Transformer Application

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In order to pick the proper power transformer for a certain application many factors must be taken into account. Each transformer location on each system must be considered separately in the light of these factors.

THE SELECTION of power transformers for generating stations and substations requires a detailed study of a large number of factors. Many economies can result from a correct choice of transformer type and characteristics; however, each application must be considered on its own merits. Conclusions reached regarding transformers for one location on a system may not apply on another system, or at another location on the same system.

The purpose of this article is to review some of the factors that should be considered in making a power transformer application. The major factors discussed are:

1. Comparison of single-phase and 3-phase transformers.
2. Transformer insulation level.
3. Types of cooling.
4. Selection of method of cooling.

COMPARISON OF SINGLE-PHASE AND 3-PHASE TRANSFORMERS

A 3-PHASE power transformation can be accomplished by a 3-phase transformer or by three single-phase units. The 3-phase unit has the advantages of greater efficiency, smaller size, and a lower installed cost when compared with a bank made up of single-phase units. The floor space required for a bank of single-phase transformers can approach twice the area required for a single 3-phase transformer. The increased bay size necessary for the single-phase units can result in a considerably higher installed cost when all factors are considered, particularly in locations where space is at a premium. This factor must be evaluated for each application because space limitations will vary between locations. The more complicated connections to a bank of single-phase transformers complicates the bus structure, further increasing the installation costs chargeable to the transformers.

The choice between single-phase and 3-phase transformers is influenced to some extent by the need for spare capacity. When three single-phase units are used in a bank, it is possible to install a fourth unit at the same location as an emergency spare. However, transformers have a proven reliability higher than most other elements of a power system, and fo this reason the need for immediately available complete spare capacity is often questionable. Today 3-phase units are used quite generally with no on-the-spot spare transformer capacity. In these cases parallel or interconnected circuits of the system may provide emergency capacity, or, for small and medium-size transformers, portable substations can provide spare capacity on short notice.

The ever-present demand for better service reliability and the consequent changes in system design have had a major influence on the selection of 3-phase transformers in distribution substations. In many applications, particularly in distribution substations serving radial subtransmission or distribution circuits, the use of a fourth single-phase transformer as a spare is not considered satisfactory unless several banks are used in the station The time required to switch the spare into service manually often rules out this method of providing spare capacity. I the spare capacity must normally be in service, the same spare capacity is required with either single- or 3-phase transformers.

Many factors in system design have decreased the dependence on any one transformer bank for maintaining service continuity. Examples are the unit system design in generating stations and the primary network system These factors have contributed to the trend toward the general use of 3-phase transformers.

Handling and shipping limitations made it necessar to use single-phase transformers for many applications jus a few years ago. Transformer developments, including improved steel, the form-fit construction, and forced cooling, have contributed to a radical reduction in weight and dimensions. Today, all but the very largest rating can be built and shipped as 3-phase units.

TRANSFORMER INSULATION LEVEL

THE BASIC impulse insulation levels (BIL) of powe transformers having full insulation are given i column 2 of Table I. These levels should be used unles special study shows that a lower insulation level can b protected adequately against surge voltages. At location where 75- or 80-per cent lightning arresters can be applie close to the transformer, important economies can b realized by reducing the transformer insulation level on class, as indicated by the BIL's in column 3 of Table I These applications require a complete study of the transformer surge protection. First, it is necessary to estimat

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he maximum dynamic voltages to ground at the transormer location during normal and abnormal conditions. These voltages should never exceed the rating of the ightning arrester selected. If these studies show that the 5- or 80-per cent lightning arrester can be applied with afety, the second step is to determine the maximum permissible distance between the lightning arrester and the ransformer. The data in Table II illustrate the influence of the transformer BIL and the lightning-arrester rating on he permissible distance between a 138-kv transformer and he lightning arresters. These data were taken from Tables II and III of a paper by R. L. Witzke and T. J. Bliss,[1] and are based on the following assumptions (see Figure 1):

1. The transformer is located at the end of a single overhead transmission line.
2. The lightning arrester is connected to the bus through a T tap with a maximum of 35 feet of lead between the lightning arrester and the bus.
3. The overhead line is of steel-tower construction with a maximum of ten suspension insulators.
4. Protection is provided for a 500-kv-per-microsecond surge arriving at the station over the overhead line.
5. Station ground resistance is neglected.

Table I. Power Transformer Basic Impulse Insulation Levels

System Voltage, Kilovolts	Transformer BIL, Kilovolts	
	Full Insulation	Insulation Reduced One Class
115	550	450
138	650	550
161	750	650
230	1,050	900
287	1,300	1,050
345	1,550	1,300

Table II. Influence of Transformer BIL and Lightning-Arrester Rating on Permissible Distance Between Transformers and Lightning Arresters that Might Be Applied on a 138-Kv System*

Transformer BIL, Kilovolts	Lightning-Arrester Rating, Kilovolts	Maximum Distance, Feet
650	145	44
	121	133
550	117	45
	111	60

* See text for conditions assumed in the preparation of this table. The distances given are based on adequate line and station shielding.

Table III. Approximate Relative Cost of 3-Phase 138-Kv 550-Kv BIL Transformers with Neutral Insulation Reduced to 15-Kv Class

Type	Transformer Rating in Megavolt Amperes		
	20	50	100
OA	1.00	1.00	1.00
OA/FA	0.90	0.89	0.89
OW	0.89	0.85	0.85
OA/FOA/FOA	0.79	0.77	0.74
FOA	0.75	0.72	0.67
FOW	0.69	0.65	0.62

The distances in Table II are measured between the transformer bushing and the lightning arrester connection to the bus (distance *s* in Figure 1). It will be noted that the permissible separation distance is approximately the same for the reduced-insulation transformer protected with a 117-kv lightning arrester as for the 650-kv transformer with a 145-kv ungrounded-neutral lightning arrester, indicating that the protection for these two cases is comparable. Reducing the lightning arrester rating to 111 kv increases the permissible distance from 45 to 60 feet for the case involving reduced transformer insulation.

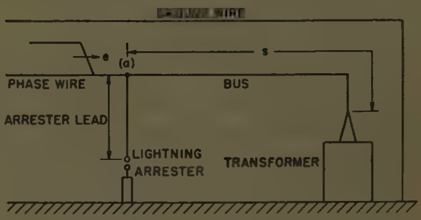

Figure 1. Circuit used in determining permissible distances between lightning arrester and transformer

The relative distances of 133 and 45 feet, for the 650 BIL protected with a 121-kv lightning arrester and the 550 BIL protected with a 117-kv lightning arrester, illustrate in a definite manner the need for having the lightning arrester closer to the transformer when reduced insulation is used.

The savings that result from decreasing the transformer insulation level one class on systems operating at 110 kv and above are very attractive, and will more than justify the additional engineering time required to determine whether or not the reduced insulation can be protected adequately against surge voltages. Further savings may be possible at 230 kv and above by reducing the transformer insulation more than one step. For example, the industry is giving consideration to an intermediate BIL of 825 kv, which is $1^1/_2$ steps below the 230-kv insulation class BIL of 1,050 kv. Some operating companies are satisfied that transformers having this basic level can be protected adequately with lightning arresters applicable to well-grounded 230-kv systems. The results of the investigation reported in reference 1 show that comparable protection is obtained with a 100-per cent lightning arrester and a 1,050-kv BIL or a 75-per cent lightning arrester with an 825-kv BIL.

The 75-per cent lightning arrester application, however, requires special study.

TYPES OF COOLING

THE BASIC TYPES of cooling are referred to by the following designations:

OA—Oil-Immersed Self-Cooled. In this type of transformer the insulating medium circulates by natural convection through external radiators.

OA/FA—Oil-Immersed Self-Cooled/Forced-Air Cooled. This type is basically an OA unit with the addition of fans to increase the rate of heat transfer from the cooling surfaces, thereby increasing the transformer rating. The higher capacity which is attained by use of fans is dependent upon the self-cooled rating of the transformer and may be calculated as follows:

For 2,500 kva (OA) and below:
  kva (FA)=1.15×kva (OA)
For 2,501 to 3,332 kva (OA):
  kva (FA)=1.55×kva (OA)−1000
For 3,333 kva (OA) and above:
  kva (F)=1.25×kva (OA)

OA/FOA/FOA—Oil-Immersed Self-Cooled/Forced-Oil-Cooled/Forced-Oil-Cooled. The rating of an oil-immersed transformer may be increased from its OA rating by the addition of both fans and oil pumps. These triple-rated transformers are usually built only in ratings of 10,000 kva (OA) and above. The maximum rating, with all fans and pumps in operation, is 1.67 times the OA rating. If the transformer is operated at the intermediate rating, using part of the fans and pumps, the rating is 1.33 times the OA rating. Automatic controls responsive to oil temperature normally are used to start the fans and pumps in sequence as the transformer load goes up. This method of operation decreases the gradient between hot spots and average winding temperature below that obtained with fans and no forced circulation of the oil.

FOA—Oil-Immersed Forced-Oil-Cooled with Forced-Air Cooler. This type of transformer is intended for use only when both oil pumps and fans are operating, under which condition any load up to full rated load may be carried. Some designs are capable of carrying excitation current with no fans or pumps in operation, but this is not universally true. Heat transfer from oil to air is accomplished in external oil-to-air exchangers.

OW—Oil-Immersed Water-Cooled. In this type of water-cooled transformer, the cooling water flows through coils of pipe which are in contact with the insulating oil of the transformer. The oil flows around the outside of these pipe coils by natural convection, thereby effecting the desired heat transfer to the cooling water. This type has no self-cooled rating.

FOW—Oil-Immersed Forced-Oil-Cooled with Forced-Water Cooler. External oil-to-water heat exchangers are used in this type of unit to transfer heat from oil to cooling water; otherwise the transformer is similar to the FOA type.

SELECTION OF METHOD OF COOLING

THE SELECTION of the method of cooling that should be used must be based on a complete engineering study, each application being considered on its own merits. The following factors may have an important influence on the choice of cooling:

1. Selling price.
2. Loss evaluation.
3. Installation costs.
4. Reactive evaluation.
5. Emergency capacity.
6. Impedance.

The most important factor in the selection of the cooling method is the selling price of the transformer. Table III illustrates the relative costs of the six major types, based o approximate selling prices of 138-kv 3-phase transformer having 115-kv class insulation. The comparison is base on transformers having the same maximum continuou rating. In each case the selling price of a self-coole transformer is used as the base price, with the cost of th other units expressed as a ratio to this base price. I will be noted that the OA is the most expensive and th FOW the least expensive for each rating given. It i evident that forced cooling will result in important saving and should be considered if the other transformer charac teristics are suitable for a given application.

Loss evaluation. One of the elusive items that must b studied in applying power transformers is loss evaluation There still exists in the industry a wide difference o opinion in regard to how losses should be evaluated. A a complete discussion of this factor is beyond the scope o this article, the influence of loss evaluation on the cost o the different transformers by varying the capitalized cos of losses over a range that might be experienced in practic is shown. In this analysis the losses are capitalized an added to the selling price of the transformer, rather tha using the alternative procedure of calculating annual costs

The capitalized cost of losses should include an energ charge as well as an equitable demand charge. The curve in Figure 2 may be used to determine the first componen of the charge once the loss factor, energy charge, an carrying charge are known. For example, with a 50-pe cent loss factor, an energy charge of four mils per kilowa hour, and a 12-per cent carrying charge, the energ component of the loss is capitalized at $150 per kilowat The second component is a function of the additiona system investment required to supply the losses durin peak load periods. The total capitalized cost of a loss taken as the sum of the two components.

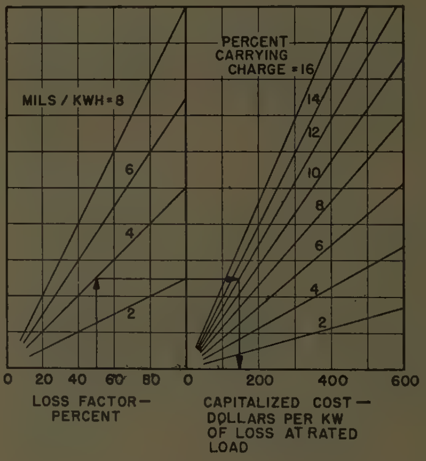

Figure 2. Chart fo estimating capitalize cost of losses

As used in this discussion, loss factor is defined as follow

$$\text{Loss Factor} = \frac{\text{Average annual loss}}{\text{Loss at rated load}} \times 100 \text{ per cent}$$

A 100,000-kva 3-phase 138-kv transformer having BIL of 550 kv at the line terminals and 15-kv-class insulatio at the neutral will be used to illustrate the influence of lo able IV. Selling Prices, Loss Products, and Loss Ratios for 00,000 Kva 3-Phase 138-Kv 550-Kv BIL Transformers with Neutral Insulation Reduced to 15-Kv Class**

Type	Approximate Selling Price, Dollars per Kilovolt Ampere**	Loss Product	Loss Ratio
A	2.48	0.043	1.5—2.75
A/FA	2.19	0.049*	1.5—2.75*
A/FOA/FOA	1.85	0.058*	1.5—2.75*
OA	1.67	0.059†	1.2—2.0†

Based on OA rating.

Based on 57,000 kva.

* The prices used in preparation of this paper were those in effect during October, 950.

able V. Comparison of Capitalized Costs of 100,000-Kva 138-v 550-Kv BIL OA and FOA Transformers with Neutral Insulation Reduced to 15-Kv Class

	OA		FOA	
osses, kilowatts:				
ron	146.6		126.3	
ans and pumps			41.7	
opper	293.2		467.3	
eactive losses, kilovolt amperes:				
xcitation	1,173		1,010	
X	7,500		11,250	
otal reactive losses	8,673		12,260	
valuations:				
ron loss	$400/kw		$400/kw	
ans and pumps			$400/kw	
opper loss	$200/kw		$200/kw	
eactive	$7/kva		$7/kva	
osts:				
elling price	$247,618	45.0%	$167,480	33.6%
ron loss	58,640	10.7	50,520	10.2
ans and pumps			16,680	3.4
opper loss	58,640	10.7	93,460	18.7
eactive	60,711	11.1	85,820	17.3
ubtotal	$425,609		$413,960	
nstallation*	123,809	22.5	83,740	16.8
otal	$549,418	100.0%	$497,700	100.0%

Installation included at 50 per cent of transformer selling price.

valuation on the capitalized cost of a power transformer. The essential data for this study are summarized in Table V. The transformer losses can be obtained from the loss roducts and ratios as follows:

er cent iron loss $=\sqrt{\text{Product/Ratio}}$
er cent copper loss $=$ Ratio $\times$ per cent iron loss

here

roduct = product of per cent iron loss and per cent copper loss
atio = ratio of copper loss to iron loss

In using these products and ratios, it should be noted hat the values are not expressed in terms of the maximum ating of the forced-cooled transformers. For example, he loss product and ratio for the FOA design are expressed n a base equal to 57 per cent of the maximum rating. To change the base, the loss ratio is multiplied by the quare of the ratio of the new base over the old base, while he loss product remains the same. Fan losses for an OA/FA transformer are included at two per cent of the otal loss, and pump and fan losses of the OA/FOA/FOA nd FOA transformers at seven per cent of the total loss. To permit generalization independent of the actual fan nd pump duty cycles, these losses are capitalized the same as iron loss. In the following discussion, the capitalized cost of losses is the sum of the capitalized energy charge from Figure 2 and the appropriate demand charge.

Curve II in Figure 3 shows the influence of the capitalized cost of losses on the cost of an FOA transformer. The FOA cost is expressed as a ratio to the cost of an OA transformer. In each case the copper-to-iron loss ratio has been selected to give the lowest loss capitalization, giving due consideration to the limits in Table IV. Curves II, III, and IV in Figure 3 are calculated on the basis that the iron loss and copper loss are evaluated at the same rate for copper loss evaluations of $300 or more per kilowatt. For copper loss evaluations of less than $300 per kilowatt, the iron loss is capitalized at a constant value of $300 per kilowatt. This procedure was justified because variations in iron loss evaluation, compared with variations introduced by other factors, have a small influence on the cost ratio. The points shown on Figure 3 for iron loss capitalized at $200 and $400 per kilowatt illustrate the influence of this variation. Varying the copper loss evaluation between $100 and $400 influences the cost ratio by about 25 per cent, indicating the importance of having reasonably accurate data on this factor. Curve I, which is based on the selling price of the transformer, is included for comparison.

Installation costs will have an important influence on the method of cooling that should be selected for a given application. As this factor varies through a wide range depending on local conditions, it is not possible to evaluate this factor accurately in any general comparison. Curve III is based on an installed cost equal to 150 per cent of the selling price of the transformer and is included to emphasize the importance of including installation costs in making comparisons. This is not intended to be any accurate comparison, because installation costs vary considerably and may be different percentages for each type of cooling. Curve III also includes capitalized losses. It will be noted that installation costs decrease the spread in the cost ratio introduced by variations in the capitalized cost of copper losses.

As the reactance of an FOA transformer is higher than for an OA transformer, some evaluation should be placed on the reactive requirements of the transformers. Curve IV includes this factor as well as installed costs and capi-

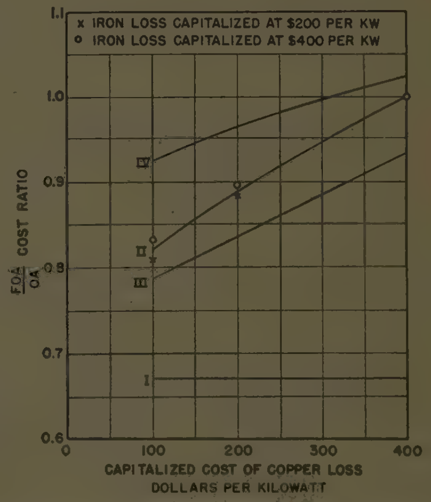

Figure 3. Capitalized cost of 100,000-kva 138-kv 3-phase FOA transformer expressed in per unit of capitalized cost of corresponding OA transformer

I. Transformer selling price
II. Selling price and capitalized losses
III. Installed cost and capitalized losses
IV. Installed cost, capitalized losses, and reactive power requirements

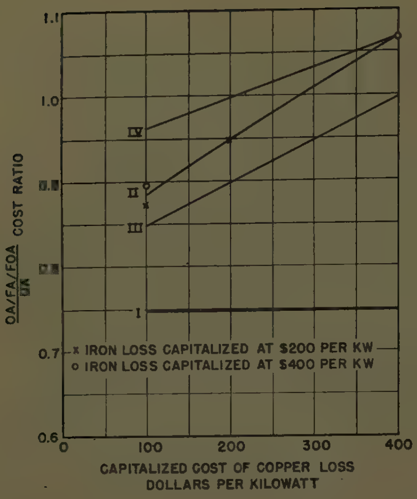

Figure 4. Capitalized cost of 100,000-kva 138-kv 3-phase OA/FOA/FOA transformer expressed in per unit of capitalized cost of corresponding OA transformer

I. Transformer selling price
II. Selling price and capitalized losses
III. Installed cost and capitalized losses
IV. Installed cost and capitalized losses and reactive power requirements

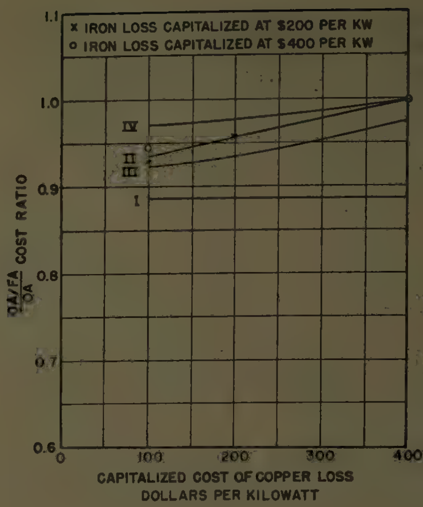

Figure 5. Capitalize cost of 100,000-k 138-kv 3-phase OA FA transformer e pressed in per un of capitalized cost corresponding O transformer

I. Transformer sel ing price
II. Selling price an capitalized losses
III. Installed cost an capitalized losses
IV. Installed cos and capitalized loss and reactive pow requirements

talized losses. The reactances were taken as 7.5 per cent for the OA transformer and 11.25 per cent for the FOA transformer. Excitation requirements also are included at eight times the iron loss. Curve IV is based on an outside figure of $10 per reactive kilovolt ampere. Direct interpolation between Curves III and IV is permissible if the reactive power is evaluated at less than $10 per kilovolt ampere. The spread between Curves III and IV shows that the reactive requirements of transformers have an important influence on the cost ratio.

Figures 4 and 5 illustrate a similar cost comparison for the OA/FOA/FOA and OA/FA transformers.

Table V summarizes the costs included for one of the cases plotted in Figure 3. No-load losses are capitalized at $400 per kilowatt and load losses at $200 per kilowatt. Reactive power is evaluated at $7 per kilovolt ampere instead of the outside figure of $10 per kilovolt ampere used in Figure 3. It will be noted that reactive charges account for 16.0 per cent of the total cost of the FOA transformer. Actually, if reactive power were evaluated at as high as $7 per kilovolt ampere, consideration should be given to a more expensive, lower reactance transformer. Including installation costs at the same percentage for both transformers may not result in a fair comparison. The installation costs may be a higher percentage of the transformer selling price for FOA than for OA transformers.

In stations where on-the-spot spare transformer capacity is to be provided, the OA/FA and OA/FOA/FOA transformers have definite merit. In these cases these transformers could be operated within their self-cooled ratings normally, with the forced ratings reserved for emergency conditions, or the triple-rated unit could be operated within its FA rating normally, with its maximum rating reserved for emergencies. In these applications the losses would be evaluated on the basis of the lower normal loading, which would be equivalent to using a lower copper loss evaluation in Figures 4 and 5. It also would seem reasonable to evaluate the cost of the transformer reactive power at the normal fractional load, which decreases the forced-cooled/self-cooled transformer cost ratios. As an example, consider an 80,000/100,000-kva OA/FA transformer normally operated within its OA rating, with the FA rating reserved for emergencies. Also assume that copper losses are evaluated at $200 per kil watt and reactive power at $10 per kilovolt ampere the transformer location. Following the philosophy di cussed, the copper loss would be evaluated at 0.64×20 or $128 per kilowatt in using Figure 4. Reactive cos would be evaluated at $6.40 per kilovolt ampere.

The higher impedance of the forced-cooled transforme may have merit in locations where the short-circuit kilovo amperage approaches the rating of the installed circu breakers. On the other hand, this higher impedance ma unfavorably influence steady-state or transient stabilit limits in certain locations on a system. These facto should not be overlooked in selecting power transforme for specific applications.

REFERENCE

1. Co-ordination of Lightning Arrester Location with Transformer Insulation Lev R. L. Witzke, T. J. Bliss. AIEE *Transactions*, volume 69, part II, 1950, pages 964–7

Handie-Talkie Portables Used for Defense

The first of a series of air-raid tests was recently co ducted in Rockefeller Center, New York City, to study th efficiency of personnel and equipment under simulated ai raid conditions. The test brought into action a repr sentative portion of the Center's civilian defense pla The total organization includes more than 1,000 volu teers, and utilizes a wide variety of special equipmen including the use of Motorola frequency-modulated 2-wa "Handie-Talkie" portable radiophones and Pack Se which were recently purchased to permit instantaneo contact between points anywhere on the 12-acre develo ment. Plans call for distribution of the sets througho the various buildings, which will enable defense instru tions to be circulated throughout the Center's 15 building The recent test marked the first application of a compr hensive civilian defense program which was instituted la August with the formation of a 6-man civilian defen committee for the Center.

A Color Television System for Industry

H. R. SMITH A. L. OLSON R. F. COTELLESSA

A COMPARATIVELY low-cost nonbroadcast wired system especially adapted to manufacturing, merchandisng, medicinal, and military fields has been developed round the image orthicon pickup tube.

A field sequential system involving rotating color disks vas decided upon since, in the present state of the art, this ystem would prove simplest to operate for relatively unrained industrial personnel. Such a system would not uffer serious disadvantages imposed on it by present-day elevision broadcast standards; also, since relatively small nonitors are used, the problems of excessively large motors nd rotating disks are not present.

In order to obtain a flickerless high-resolution presentaion comparable to that of present-day television studio quipment, a 525-line 180-field 3-color system was chosen. n 18-megacycle bandwidth is required to give the desired igh resolution while the scanning frequencies chosen pernit locking the synchronizing generator to the 60-cycle ower line to minimize hum problems. It is, however, till possible to have misregistry since the three color fields ccur at different hum field levels. These standards permit elatively simple modifications and additions to a standard amera chain and have the further advantage that all notors can be of the synchronous type, thus eliminating ulky motor speed-controller circuits. Color breakup of a ast-moving object is also greatly reduced by means of the igh sweep rates.

The chain consists of the following units: pickup head, amera control unit, 7-inch color monitor with a removable olor wheel assembly, sync generator, and a low-voltage ower supply. All units are built-in portable carrying ases, as shown in Figure 1. The pickup head consists of wo units, the camera head proper and an electronic viewinder displaying a black-and-white picture. The camera eatures a lens turret rotatable from the back of the camera vith provisions for four lenses.

Figure 1. Units of the industrial color camera chain

A block diagram of the system is shown in Figure 2, and ts operation can be traced through from the pickup head as ollows: the video signal from the camera preamplifier is simultaneously fed to the viewfinder and to the low-voltage supply which acts as a distribution point. From this point the signal is fed to the control unit where it is separated into its three color components to permit individual color gain control. The signals then are recombined and have blanking, shading, and sync signals inserted. The composite signal then is fed to a line output terminal and to the color monitor through the power supply. A distribution amplifier providing five outputs with a maximum gain of two can be supplied for distribution of the signal to remote monitors.

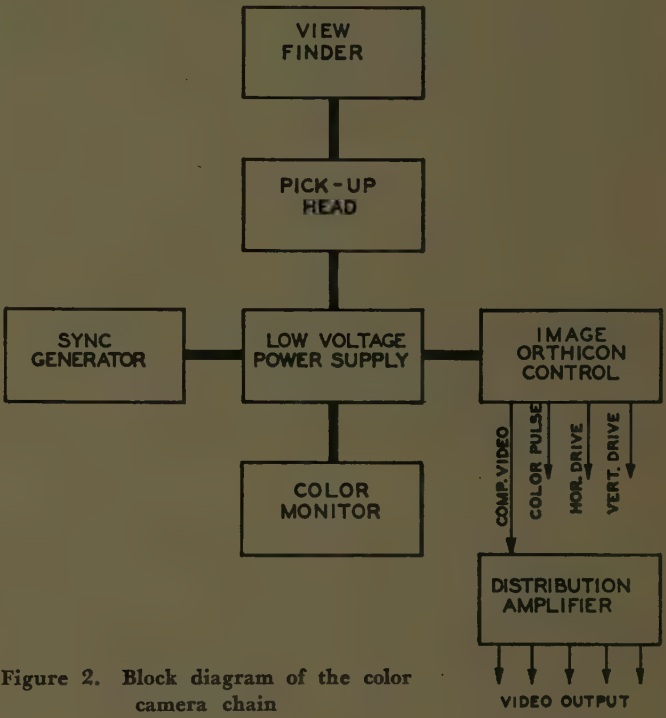

Figure 2. Block diagram of the color camera chain

The motors used are geared to their respective color wheels through a toothed rubber belt and mounted to permit manual phasing by rotation of the motor in its mount. This setting is made once and usually requires no further adjustment.

The following equation has been successfully used to predict the approximate horsepower required to drive a properly balanced wheel:

$$\text{Horsepower} = 12 \times 10^{-11} \ (\text{rpm})^3 \times (\text{radius in feet})^5$$

This is an empirical expression for a synchronous motor; a push-button switch is provided for each motor to permit manual selection of the correct phase.

Digest of paper 51-114, "A Color Television System for Industry," recommended by the AIEE Committee on Television and Aural Broadcasting Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Not scheduled for publication in AIEE *Transactions*.

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Germanium Trigger Photocells

F. A. STAHL

Trigger cell behavior results from the occurrence of n-type and p-type germanium in the same crystal, so arranged that both are in the contact circuit. This photocell is especially well adapted for use in the field of on-off devices and, as its on-current is high enough to develop useful power in low resistances, it can actuate short-time constant computer circuits without preamplifiers and cathode followers.

THE CONVERSION of radiant energy into electric energy for purposes of measurement and control and for the transmission and reception of intelligence has long been a field of active study. One of the most versatile newcomers to the growing list of photoelectric transducers is the germanium photocell.

In general, three modes of operation are attainable in these photocells. First, they exhibit both photoconductive and photovoltaic effects; that is, with an applied voltage, the current is a function of radiation intensity, while in the absence of applied voltage, an electromotive force is generated by the incident radiation. In addition, a composite effect can be achieved, resulting in a trigger cell. Any of the three types of characteristics can be emphasized by the selective control of factors such as the nature of the germanium crystal surface.

The spectral response of these photocells is shown in Figure 1. It extends from about 0.6 micron in the yellow to a peak at about 1.6 microns in the infrared, and then decreases rapidly to a threshold at about 1.9 microns. The maximum efficiency is therefore in the near infrared region. The spectral response curve of the eye is shown for comparison, normalized to the same relative height.

In its simplest form the germanium photocell is a point-contact crystal diode, with the conductivity of the contact controlled by the incident radiation intensity. The major photocurrent is observed with the voltage applied in the high-resistance direction; this is generally true in semiconductor photocells. The *1N77* is a cell of this type for which tentative design data have been announced. Its operation is characterized by linearity extending to fairly high levels of voltage and of intensity.

In the photovoltaic cell, the electromotive force generated by radiation is limited by internal factors to a few tenths of a volt, and the electromotive force-intensity curve is consequently a saturation characteristic, as shown in Figure 2.

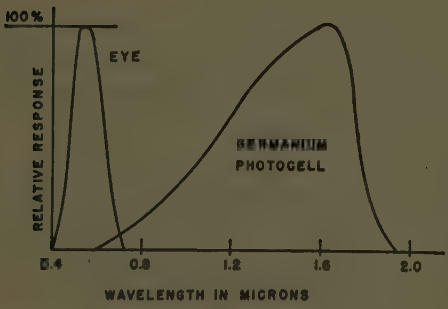

Figure 1. Spectral response of germanium photocells compared with that of the eye

The outstanding feature o this type of cell is its sensitivity to extremely low level of incident radiation, becaus the slope of the characteristi is steepest at the low-leve end. In approaching th threshold, the curve actuall is linear over several order of magnitude. Intensitie down to fractions of a microwatt per square centimeter can be detected readily be cause the internal noise level in the absence of applie voltage is very low.

The third general type of germanium photocell is th trigger cell, basically a low-voltage high-current devic actuated by infrared light. As shown in Figure 3, th current-voltage characteristic is a double saturation curv with the level of the variable plateau determined by th intensity. These cells are of special interest because their relatively large power-handling capabilities.

BACKGROUND OF THE TRIGGER CELL

CHARACTERISTICS of the type found in trigger cells wer studied at Purdue University, Sperry Gyroscop Company, and Massachusetts Institute of Technology som eight years ago in early research on photoeffects in ger manium.[1] The early observations as well as recent d velopments show that trigger cell behavior is the result the occurrence of *n*-type and *p*-type germanium in the sam crystal, so arranged that both are part of the contact circui This composite contact structure is illustrated in Figure 4.

The behavior of composite contacts can best be studie

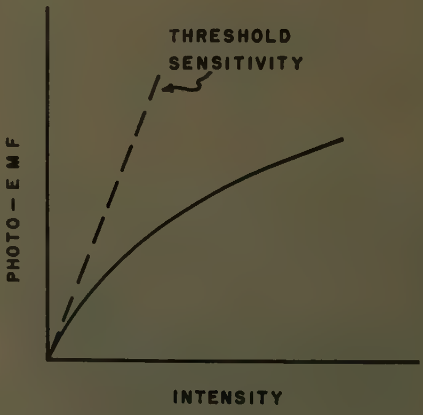

Figure 2. Vari tion in photoele tromotive for with radiation i tensity. The vol age sensitivity any point is th slope of the curv

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Full text of a conference paper presented at the AIEE Winter General Meeting, N York, N. Y., January 22–26, 1951. Recommended by the Committee on the P duction and Application of Light.

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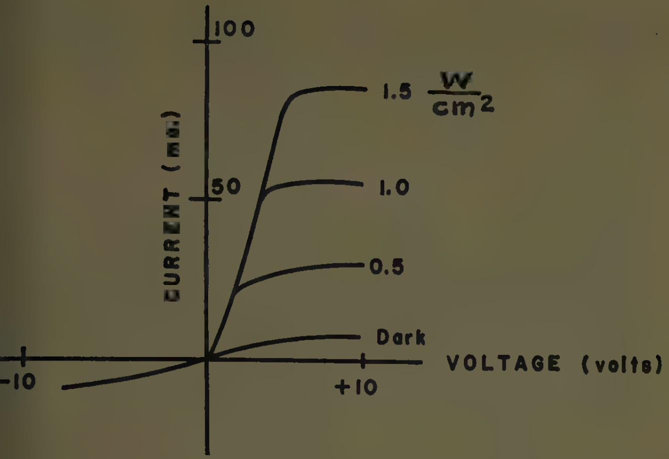
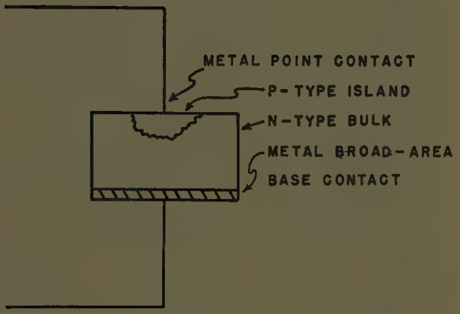
The author wishes to express her appreciation for the assistance and encouragement her colleagues, especially George D. O'Neill and Dr. Bernard J. Rothlein.



igure 3. Operating characteristic of a typical saturation-type germanium trigger cell



igure 4. Cross ection of contact ructure in a germanium trigger cell

y a brief analysis of the nature of single contacts involving -type and *p*-type germanium separately.[2] One of the asic functions determined by the conductivity type in a emiconductor is the rectification polarity of a metal point ontact on the crystal surface. The letter designation of he type, *n* or *p*, is the sign of the semiconductor for the high-onductivity direction. The contact between *p*-type and *n*-ype portions of a crystal will also rectify, such contacts eing referred to as *p-n* junctions. High current flows hen the applied voltage is positive at the *p*-type side of the inction and negative at the *n*-type side. Figure 5 is a omparative representation of the rectification characteriscs of these contacts. The polarity indicated is that of the etal contact, except for the case of the *p-n* junction, for hich the *p*-type section is the reference.

The composite contact is a series circuit containing a etal point contact, a *p*-type section, and an *n*-type section. he combination behaves as two rectifiers in series opposion. Because of the relative polarities, each contact locks the forward current of the other, so that the net conuction curve consists of the inverse halves of the individual haracteristics. This is the double saturation curve found xperimentally.

ACTION OF LIGHT

THE BASIC ACTION of radiation quanta absorbed at a single rectifying contact is the release of normally bound harges from the valence bonds of the germanium atoms. he action is illustrated in Figure 6, which shows the field onfiguration for a metal contact on *n*-type germanium. he barrier region is that portion of the semiconductor in which the potential levels curve to meet corresponding levels in the metal. Ordinarily, electrons in the semiconductor occupy positions close to the nuclei of the atoms, with energies in the range designated "valence-bond band." With the additional energy received from a photon, the electron energy may be raised to the range marked "conduction band"; energy levels in the intervening range are forbidden by quantum-mechanical considerations.

Electrons with energies in the conduction band will move under the influence of the barrier field and any external field which may be superimposed. The energized electron leaves behind a vacant position which is called a hole. By a succession of neutralizations with neighboring valence electrons, the hole, which behaves as a positive charge, can drift within the valence-bond band in the direction of the electric field. As a general definition, it can be stated that a semiconductor in which electrons carry the current is *n*-type, and one in which holes carry the current is *p*-type. In both

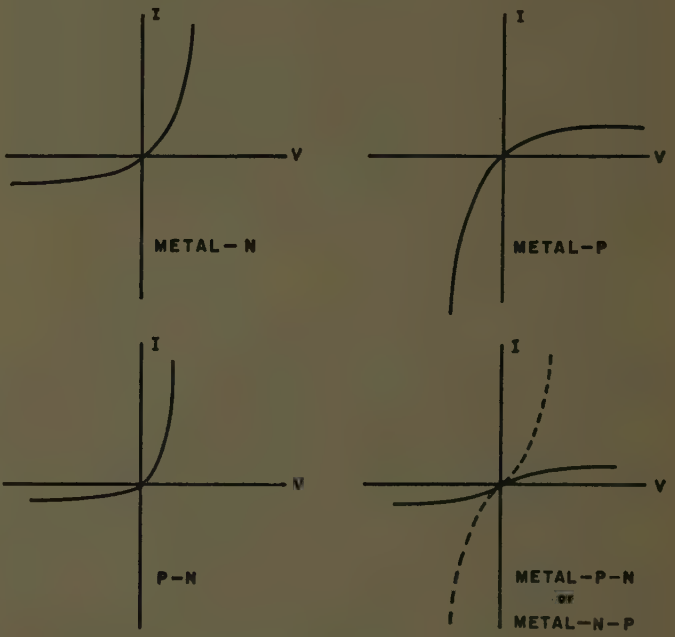


Figure 5. Rectification characteristic of metal-p, metal-n, p-n, and composite contacts respectively. In the case of the composite contact, the barrier in each section blocks the forward current of the other so that the net conduction curve consists of the inverse halves of the individual characteristics

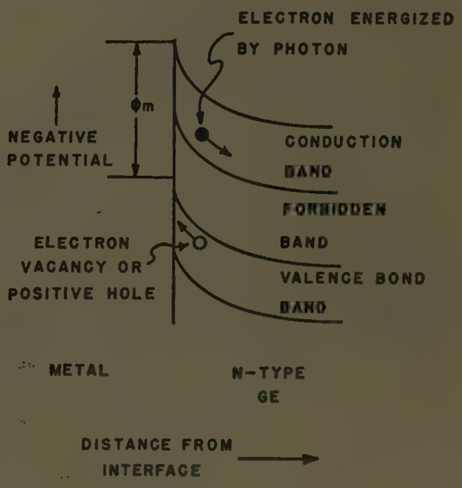


Figure 6. Field diagram of a metal-n contact, showing the mechanism of the photocurrent

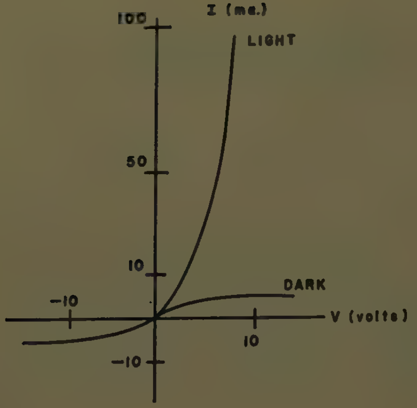


Figure 7. Operating characteristic of a typical breakdown-type germanium trigger cell

cases, the drift of the photon-energized charges in the field constitutes the primary photocurrent.

As a secondary effect, the conductivity of a metal-semiconductor contact is increased because of the higher concentration of mobile charges and the circuit tends to draw added current from the voltage source. As mentioned previously, the major photoresponse is observed in the back direction. The cumulative effect at very high radiation intensities results in an appreciable reduction in the value of inverse voltage at which the rectification characteristic breaks down. The peak inverse voltage of an initially low breakdown contact can be reduced almost to zero by sufficient intensity.

PHOTOEFFECTS WITH COMPOSITE CONTACTS

RADIATION incident on a composite contact is absorbed mostly in the region of the outer barrier. The primary photoeffect is a current proportional to the intensity and in the inverse direction relative to the outer contact. Thus, in the case of the metal-*p*-*n* configuration, the photocurrent will be positive, because for the metal-*p*-type contact the inverse direction is that in which the metal is more positive than the germanium. The effect of the photocurrent on the conduction characteristic is to separate the saturated portions of the curve so that the step-shaped family of Figure 3 is generated. The slopes of the corresponding plateaus are seen to be substantially equal for t
range of intensity levels in which the photoresponse rema
a primary effect. Once the radiation-liberated char
have been swept out of the contact region, further incre
in voltage cannot produce a current increase beyond t
allowed by normal conductivity. The step is quite sha
and represents a voltage change of a few tenths of a volt

Where the outer contact has the initially low breakdo
previously mentioned, secondary effects become apprecia
at operating conditions for which saturation would oth
wise occur. Instead, breakdown occurs upon the appli
tion of the radiation beam, and the forward current of
inner contact flows through the circuit. A curve show
this action is illustrated in Figure 7; in the presence
radiation, the characteristic looks like that of a normal re
fier. Current ratios of 30 are obtained in breakdown-t
trigger cells, while a ratio of 10 can be achieved in
swing of the plateau for the saturation-type units.

The basic circuit requirements for best operation of b
these photocells are low voltage and low resistance. A
sistive load is recommended since some current limitin
desirable at extreme levels.

The general applicability of trigger cells is in the field
on-off devices. The on-current is high enough to deve
useful power in low resistances. Thus the cell can actu
short-time constant computer circuits directly without
course to preamplifiers and cathode followers. Its o
internal speed of response is so high that interrupted li
can be followed beyond 10^5 cycles per second, represent
a square-wave response good to more than 10^4 repetiti
per second. The frequency response drops off to some
tent at intensities of 2 or 3 watts per square centime
where secondary effects become so large that the time la
appreciable.

In addition to operating as a relay itself, the germani
trigger cell can be used to operate an electromechanical
lay and thereby actuate large-scale systems such as alarms
motors. Here it should be emphasized that since these c
are operated most efficiently with infrared beams, secr
of signaling or of alarm-system protection is available.

The active area of germanium trigger cells is of the sa
order as that of the photoconductive and photovolt
cells, namely, between 10^{-4} and 10^{-3} square centime
These cells are therefore capable of the same degree
optical resolution. Also, they can be constructed in
same general form as the *1N77*, which is shown in Figure
One hundred of these units can fit into a cross section of
square inch. A bank of such elements can be utilized
such complex operations as high-speed pulse counti
Gas-discharge lamps are excellent sources of pulsed light
such applications.

The few general examples which have been given sh
that the potential uses of germanium trigger photocells
extensive and varied. Further development will undou
edly show greater possibilities.

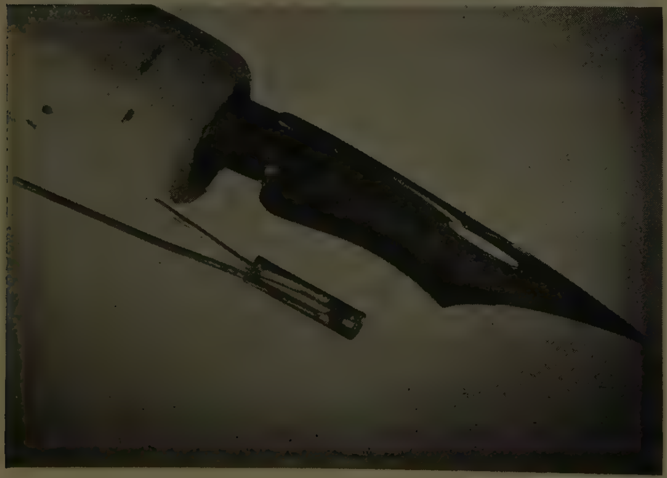


Figure 8. A germanium photoconductive cell, type 1N77, comparing size with that of a pen. Trigger cells can be constructed in similar form

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New High-Voltage Insulation for Stator Windings

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A NEW TYPE OF synthetic resin-bonded mica tape
insulation has been developed for high-voltage
achine stator windings and is being applied widely to tur-
ne generators. This new insulation has improved physi-
l, electrical, and thermal properties as compared to
rlier forms of high-voltage machine insulation. The
sulation consists of multiple layers of continuous mica
pe impregnated with a solventless heat-reactive resin.

The impregnant plays a very important role for it serves
the mica bond and determines to a large extent the
echanical and electrical properties of the composite
sulation. The impregnant developed consists of a resin,
longing to a class of synthetic resins known as linear
lyesters, which is dissolved in a special heat-reactive
onomeric resin. This combination of resins can be
pregnated easily into the mica tape insulation at ordinary
mperatures because it is flowing quite freely before the
polymerizing reaction takes place. After the composite
sin is in place and heat is applied, the components react
ith each other to produce a cross-linked thermosetting
lid resin. This final reaction occurs without the forma-
n of any gaseous or liquid by-products, thus making pos-
le almost complete filling of the void spaces. The
pregnating resin has excellent electrical properties. Not
ly is the power factor appreciably lower than for the
phaltic compound, but it is also almost independent of
mperature up to 125 degrees centigrade. The mechani-
l properties are as important as the electrical properties in
is application and, therefore, the behavior of the resin
der load was carefully investigated. Upon application
a load there is an instantaneous elastic elongation which
followed by a gradual further elongation. This behavior
reversed almost completely when the load is removed.
is elastic recovery provides restoring force when the
sulation is displaced during temperature cycles.

The mica tape used is bonded with a synthetic resin with
cellent electrical properties which contribute to low dielec-
c loss and high dielectric strength. The mica tape is
plied without employing brushing bond between layers
ch as was necessary with asphalt-bonded tape. The
mination of the brushing bond makes application of the
pe easier and the increased physical strength of this tape
cilitates tight application which results in better control of
electric quality level. The process requires no multiple
termediate impregnations, such as required with asphalt
pregnant, as all the tape is applied before impregnation.
ter application of all layers of the mica tape, the coil is
ped over-all with a Fiberglas tape for binding and finishing. Next the coils are heated and evacuated at high vacuum to remove moisture, solvents, and gases. They then are vacuum-pressure impregnated with the new solventless synthetic resin. After impregnation, the resin is cured by heating while there is physical restraint of the insulation both on the straight part and the end winding. This processing results in consolidation of the insulation and reduction of internal voids to an extent never before feasible.

The physical properties of the new insulation are improved materially. The increase in tensile strength of the new insulation is more than 3-to-1 at room temperature and is more than 30-to-1 at operating temperature (100 degrees centigrade) as compared to the asphalt-bonded insulation. Tests on insulation samples were supplemented by simulated shock tests on full-size coils as well as short-circuit tests on complete windings. These tests confirm the greater strength of the new insulation and its ability, when properly supported, to withstand expected physical loads during normal operation and occasional short circuits.

An important part of this development consisted of studying the effect of differential expansion of iron, copper, and insulation. Studies clearly indicated the continued creep of the asphalt-bonded mica insulation and the inherent stability of the synthetic resin-bonded mica. In no case did any observable separation or crack occur in the synthetic resin-bonded mica tape insulation during tests, whereas various degrees of insulation migration and tape separation were produced on coils with asphalt-bonded insulation under identical conditions.

The power factor of the synthetic resin-impregnated mica insulation is lower than the power factor of the corresponding asphalt-bonded mica. At operating voltage and temperature the power factor of the new insulation is approximately one-third that of the older insulation. The temperature effect on the power factor of the new insulation is negligible, but the power factor of asphalt-bonded mica rises sharply with temperature increase.

This new type of synthetic resin-bonded insulation offers promise of even greater reliability for high-voltage machines. The basic insulation is mica, which has been proved through more than 50 years of successful service. The new insulation substitutes a solid, yet elastic, bond for the rigid, brittle shellac bond and the plastic semiliquid asphalt bond previously used. It makes available the good intrinsic dielectric properties of mica to a greater degree than was obtainable heretofore. The insulation wall possesses the inherent ability of accommodating itself to the deformation resulting from differential thermal expansion of iron, copper, and insulation. The new insulation bond possesses greater physical strength than the inherent interlaminar strength of mica itself. The resin bond and processing technique result in improvement in dielectric characteristics such as power factor, dielectric strength, and voltage endurance.

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est of paper 51-121, "A New High-Voltage Insulation for Turbine-Generator
tor Windings," recommended by the AIEE Committee on Rotating Machinery
approved by the AIEE Technical Program Committee for presentation at the
EE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled
publication in AIEE *Transactions*, volume 70, 1951.

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ctric Corporation, East Pittsburgh, Pa.

69-Kv Medium-Pressure Gas-Filled Cable

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LOAD GROWTH in 1947 in the Washington, D. C., area necessitated starting construction of a generating station in Alexandria, Va., approximately four miles south of the territory served by the Potomac Electric Power Company. The ultimate capacity of this station is five 80,000-kw 85-per cent power factor machines to be placed on the line at approximately 1-year intervals. Intervening air fields and park territory rendered overhead transmission impractical and the problem became one of underground cable. For economical reasons, it was decided to install cable capacity for each generator as it became available.

As a basis for determining the type of cable to be used, studies were made at 115 and 69 kv using as a unit the delivery of 90,000 kva at 75-per cent load factor and 25 degrees centigrade earth ambient to the Pentagon area. Considered from the viewpoint of the initial installation only, a pipe-type cable at 115 kv was the most economical of all cables considered. However, this saving would be offset by the cost of additional pipe and excavation for future circuits.

Further, the narrowness of the available right of way would not permit adequate spacing of the pipes for heat dissipation and transmission at 115 kv would require transformation costs to tie into the existing 69-kv system. For some of the same reasons, the study at 69 kv resolved itself into the consideration of two 3-conductor cables each rated 45,000 kva, conduit for the ultimate capacity to be constructed initially. The first cost of low-pressure oil-filled cable was slightly less than that of medium-pressure gas-filled cable but this would be offset by the heavy outlay of labor and high operation and maintenance costs. A medium-pressure gas-filled cable having 600,000 circular mils, compack sector conductors, and a neoprene jacket in place of the conventional outer lead sheath, was adopted. The inner lead sheath under compression of the reinforcing tapes would have a life of three to five times that of an outer lead sheath. Failure of this outer sheath from bending or corrosion would permit galvanic action between the reinforcing tapes and the inner lead offsetting its added lif

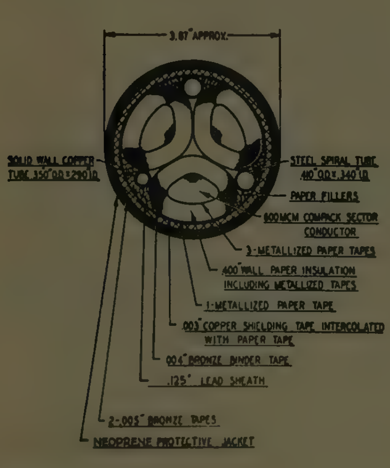
3.87" APPROX.
SOLID WALL COPPER TUBE .350" OD × .290 ID
STEEL SPIRAL TUBE .410" OD × .340 ID
PAPER FILLERS
600MCM COMPACK SECTOR CONDUCTOR
3-METALLIZED PAPER TAPES
.400" WALL PAPER INSULATION INCLUDING METALLIZED TAPES
1-METALLIZED PAPER TAPE
.003" COPPER SHIELDING TAPE INTERCOLATED WITH PAPER TAPE
.004" BRONZE BINDER TAPE
.125" LEAD SHEATH
2-.005" BRONZE TAPES
NEOPRENE PROTECTIVE JACKET

Figure 1. Cross section of cable

In the event of the passage of some moisture through th neoprene jacket, it would be filtered or become gaseo and therefore harmless. The neoprene jacket exhibits r fatigue under bending with the result that bending rad are figured on the diameter of the inner lead sheath pe mitting a reduction in the size of the manholes. A fin advantage of the neoprene-jacketed cable is its light weight. In the final design asbestos-neoprene tape and neoprene-filled tape were placed over the lead sheath as second line of defense against galvanic action.

Except for added insulation the body of the cable join is of the same type as that employed for low-pressure ga filled cable. Crepe paper is used for the insulating mediu The spun copper casing has no external tubing, a speci fitting being provided to permit the reading of the differe tial gas pressure in the adjacent joint. At each end of th joint a special seal is built up from beyond the end of th neoprene jacket to the joint casing.

The cable is terminated through a spun copper phasi spreader to single-conductor 115-kv terminals. Gas supplied through a manually operated pressure regulat to the spreader.

The conduit line consists of two 4-way duct lines, 6 fe $9^1/_2$ inches on centers, made up of 5-inch thin wall Transi ducts enveloped in concrete. The ducts are brought in the 4-foot by 15-foot manholes in such manner that n manhole will contain more than two cables and neither these cables will supply the same terminal station. Throu a stretch of approximately 8,900 feet, soil conditions we such as to render a conduit line impractical. Submari cable in 1,100-foot lengths was installed anchored in ma holes which are permitted to float.

No particular difficulty was experienced in pulling th cable into the duct. For lengths approximating 600 fe the coefficient of friction varied from 0.365 to 0.474. T minimum bending radius of the cable in manholes is inches which results in an offset of 30 inches. North of th Pentagon area, 1,840-foot lengths of cable are installed Transite trays in the gallery of bridge crossing the Potom River. Use of rollers on 5-foot spacing maintained th pulling tension at a safe level.

Four cables are in service operating at a gas pressure 43 to 46 pounds per square inch. Two have been energiz in excess of a year and have given no evidence of troub or excessive movement. They have carried loads 48,000 kva, which load will be reduced as future circu are added. Temperatures are not excessive, the ma mum empty duct temperature being 37 degrees centigra

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Digest of paper 51-67, "69-Kv Medium Pressure Gas-Filled Cable, Washingt D. C.," recommended by the AIEE Committee on Insulated Conductors and appro by the AIEE Technical Program Committee for presentation at the AIEE Wi General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publica in AIEE *Transactions*, volume 70, 1951.

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A Hook-On Power Factor Meter

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A. L. NYLANDER
ASSOCIATE AIEE

NTEREST in extending the hook-on technique to measurement of 3-phase power factor has resulted in e development of a hook-on power factor meter. Pre-quisites were light weight, simple operation, and wide nge (0 to 1.0 power factor lead and lag, 100 to 600 volts, to 600 amperes).

Power factor is usually measured by a phase-sensitive flecting instrument of the crossed-coil or moving-iron pe. Such instruments, however, are limited to a small easurement range. This limitation was overcome by opting a null principle of operation. The resulting ar-ngement (Figure 1) consists of a null-reading watt-lvanometer and a calibrated cross-phase variable resistor. ower factor is measured by hooking around one conductor, nnecting the potential leads, adjusting the variable resis-r until the watt-galvanometer reads zero, then reading e power factor on the calibrated variable-resistor dial.

The power factor range and calibration are established as llows. Null balance of the galvanometer requires quad-ture relationship of moving-coil current and field flux or e current. In Figure 1, the potential circuit voltage ctor is the resultant sum of line voltage *AB* and part of e voltage *BC*—depending upon the variable-resistor tting. The angle of this vector and, therefore, of the oving-coil current vector is adjustable by the variable sistor over 60 degrees. It follows that there is associated ith each of the three line currents a particular angular nge of moving-coil current which allows galvanometer lance. A dial, calibrated in power factor for these three nges, is attached to the linear variable resistor. The al calibrations are derived trigonometrically from the ctor relations. For example, for the 0.5 to 1.0 lagging ower factor range, the fraction k of the full variable resistor tation, in terms of power factor angle θ, is

$$=\frac{\sin\theta}{\sin(120°-\theta)} \qquad (1)$$

The galvanometer sensitivity is derived from funda-ental electrodynamic wattmeter principles and the ctor relations of Figure 1, as

$$=\frac{\sqrt{1-k+k^2}}{\sin\theta[R_{eq}+(k-k^2)R_p]} \qquad (2)$$

ere, S is galvanometer deflection in radians per unit ower factor per line volt-ampere divided by the effective lvanometer constant. This constant includes the trans-rmer ratio. R_{eq} is the equivalent transformer impedance ohms with the galvanometer burden. R_p is the total riable resistance in ohms.

Careful identification of leads and scales is necessary ensure a correct interpretation of the power factor ading. The power factor reading is obtained on the ale identified by the letter corresponding to that of the hooked line. If the phase sequence is known, and the potential leads are connected in direct sequence, the red and black scale colors indicate leading and lagging power factor respectively. If the phase sequence is unknown, the value of power factor is obtained by the same method. This may be a leading or lagging power factor and can be identified by the means shown in Figure 1. When the lag-lead detector switch is opened, the series inductance produces a known phase displacement of the moving-coil current and causes the galvanometer to deflect. Galvanometer balance is restored by turning the power factor dial. Lagging or leading power factor is indicated by a higher or lower reading respectively. The lag-lead identification circuit also provides for determination of phase sequence by noting the color of the scale on which a power factor measurement and a lag-lead determination were made.

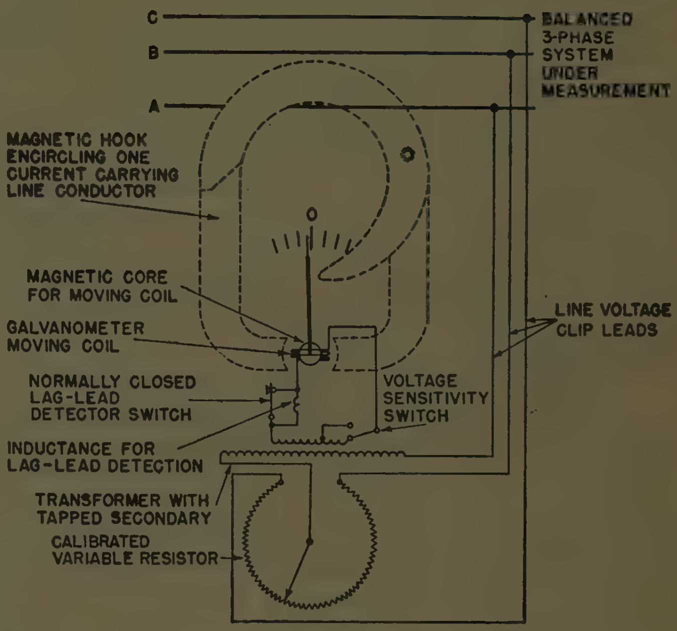
C
B
A
BALANCED 3-PHASE SYSTEM UNDER MEASUREMENT
MAGNETIC HOOK ENCIRCLING ONE CURRENT CARRYING LINE CONDUCTOR
0
MAGNETIC CORE FOR MOVING COIL
GALVANOMETER MOVING COIL
LINE VOLTAGE CLIP LEADS
NORMALLY CLOSED LAG-LEAD DETECTOR SWITCH
VOLTAGE SENSITIVITY SWITCH
INDUCTANCE FOR LAG-LEAD DETECTION
TRANSFORMER WITH TAPPED SECONDARY
CALIBRATED VARIABLE RESISTOR

Figure 1. Schematic connection diagram of the hook-on power factor meter. Power factor is measured by snapping the hook around one conductor, connecting the potential leads, turning the variable resistor until the wattmeter reads zero, then reading the power factor on the calibrated variable resistor dial

The resulting instrument has an initial accuracy of 0.01 to 0.05 power factor, and only minor errors result from such factors as voltage and current variations, incomplete hook closure, and frequency and temperature change. The meter is sufficiently sturdy to withstand the shock and abuse expected for this type of portable service instrument.

Digest of paper 51-75, "A Hook-On Power Factor Meter," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Effects of Lightning-Arrester Characteristics and Location upon Protection

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The purpose of this investigation was to study the protection provided by lightning arresters of different protective ability located various distances from the protected apparatus. Quantitative correlations of basic impulse insulation levels and surge voltages are not considered.

TO STUDY some effects of lightning-arrester protective characteristics and location on station apparatus protection, valve lightning arresters of 97-kv rating and various capacitors were connected to one end of a 1-mile test line. An impulse generator was discharged into the other end. This circuit was used to simulate 115-kv station equipment connected to a line with one mile of overhead ground-wire protection.

Relative protection afforded by lightning arresters of different discharge voltages singly and in combination was studied. The transformer was always represented by a 3,100-micromicrofarad capacitor.[1] Accessory equipment (circuit breakers, and so forth) was represented by 213- and 1,000-micromicrofarad capacitors. The test surge was a full wave of crest value slightly below that which would spark over representative 115-kv line insulation.

TEST METHOD

AN IMPULSE generator was discharged into a 1-mile test line of 4/0 steel-reinforced-aluminum-cable conductor. At the receiving end of the line, valve lightning arresters were used to protect various combinations of capacitors representing a transformer and accessory station equipment under surge conditions.[1] This test was used to represent a surge entering a 115-kv station over a line with one mile of overhead ground-wire protection.

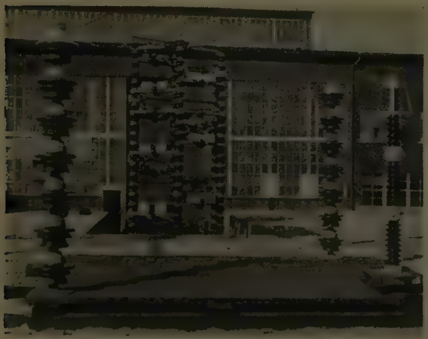


Figure 1. 97-kv lightning arrester connected for test with impulse generator in background

Figure 1 shows a 97-kv lightning arrester connected for test with the impulse generator in the background.

With the line terminated in its characteristic impedance of 450 ohms, the surge delivered into the line was negative 650 kv, 0.4 x 20 microseconds, representing a surge which would not flash over the 115-kv insulation at the end of ground-wire protection. the receiving end the sur was attenuated and distort to 590 kv, 3 x 27 micr seconds. This represents t surge arriving at the stati before being modified line termination, lightni arrester, and various station capacitances. Figure shows the front of this wave.

For comparison, all voltage values are referred front-of-wave spark-over at the AIEE rate of the 97- Thorex, Type *GP-97*, lightning arrester (298 kv) as 1 per cent. During the first few microseconds that impulse wave is impressed across a transformer, the i

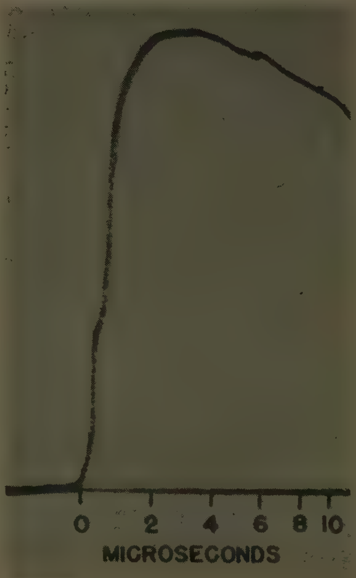


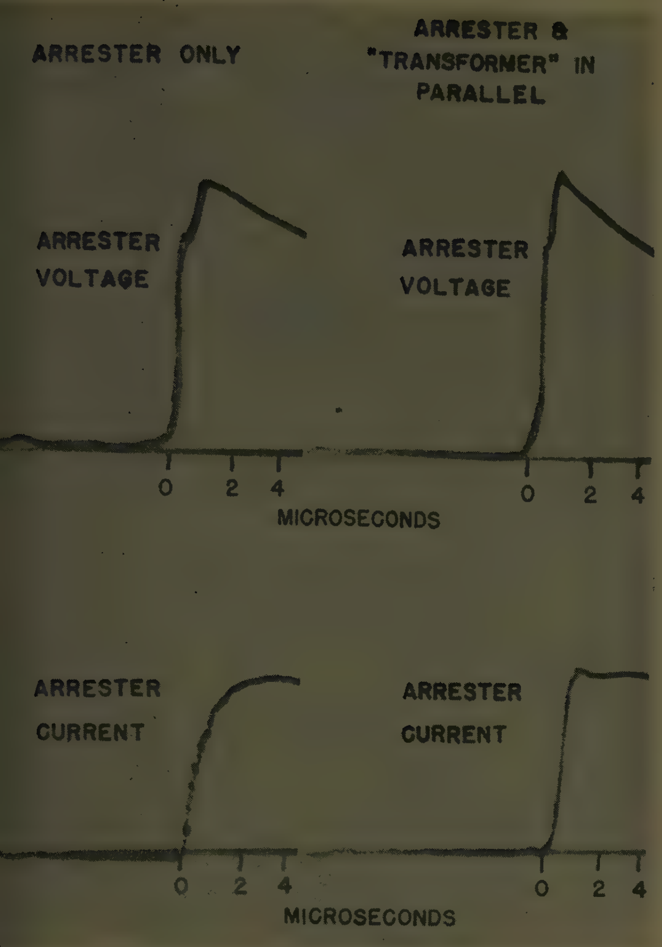
Figure 2. Surge of 590 at "station" end of 1-m test line, with line ter nated in 450-ohm char teristic impedance

portant electrical characteristic is the line-to-grou capacity of the transformer.[1] A 3,100-micromicrofar capacitor was used to represent the transformer and v be referred to as the "transformer."

The representation of a transformer under surge con tions by a capacitor probably would result in greater vo age oscillations than if a 115-kv transformer had be used.[4]

Full text of paper 51-63, "Some Effects of Lightning-Arrester Protective Characteri and Location upon Station Apparatus Protection," recommended by the AIEE C mittees on Protective Devices and Transmission and Distribution and approved by AIEE Technical Program Committee for presentation at the AIEE Winter Ge Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in A *Transactions*, volume 70, 1951.

J. W. Kalb is with The Ohio Brass Company, Barberton, Ohio.



gure 3. Lightning-arrester voltage and current with and without 3,100-micromicrofarad "transformer" in parallel

EFFECT OF TRANSFORMER ON CURRENT

ALTHOUGH transformer capacitance tends to decrease the slope of an incoming voltage surge, its effect on ghtning-arrester discharge current may be the opposite. he transformer capacitance is charged to lightning-arrester ark-over voltage and then discharges through the ghtning arrester at a rate of current rise which may xceed that obtained had the lightning arrester been onnected to the line by itself.

Figure 3 shows voltage and current oscillograms taken ith the line terminated by a 97-kv lightning arrester one and the same lightning arrester and a 3,100-micro- icrofarad "transformer" in parallel. The total lead ngth between the lightning arrester and the capacitor presenting the transformer was five feet, the minimum ossible length considering difference in height between e lightning arrester and capacitor. The voltage divider as connected directly across the lightning-arrester termi- als. The voltage and current measurements of Table taken from these oscillograms show quantitatively the fect of the "transformer" in increasing the rate of current se through the lightning arrester and its voltage.

EFFECT OF SPARK-OVER VOLTAGE

THE MARGIN of protection afforded by lightning-arrester spark-over voltage is often greater than that of the discharge voltage. Therefore the discharge voltage is frequently considered as more important when establishing lightning-arrester protection practice. However, in the protection of station equipment against incoming surges the spark-over voltage controls this discharge voltage to some degree by controlling the voltage to which the capacitance of the protected apparatus is charged. To study this effect, tests were made with the line terminated by the 3,100-micromicrofarad "transformer" in parallel with different 97-kv lightning arresters. These were: a normal 97-kv lightning arrester, 97-kv lightning arresters with gap elements having 110 and 120 per cent normal spark-over voltage, and a 97-kv lightning-arrester valve element with no gaps. As in the foregoing tests the minimum possible lead length of five feet was used to connect the lightning arrester and capacitor. Table II shows the effect of varying series-gap spark-over voltage upon crest lightning-arrester discharge voltage.

EFFECT OF SEPARATION AND LEAD LENGTH

THE FOLLOWING test results confirm what others[4–6] have found in more detailed studies: lightning-arrester lead length and separation should be kept to the minimum for best protection.

A normal 97-kv lightning arrester protecting the 3,100-micromicrofarad "transformer" allowed the crest voltages shown in Table III.

Figure 4 shows oscillograms of "transformer" voltage with the lightning arrester at the "transformer" and with the same lightning arrester separated 50 feet, with 30-foot down leads. Voltage peaks of this type are naturally not

Table I. Effect of the Transformer

	97-kv Lightning Arrester Alone	Lightning Arrester and Transformer in Parallel
Crest lightning-arrester voltage,* per cent	115	123
Crest lightning-arrester current, amperes	2,350	2,410
Effective rate of current rise (10–90 per cent), kiloamperes per microsecond	1.8	4.4

* Per cent of 298-kv front-of-wave spark-over voltage of Thorex *GP-97* lightning arrester

Table II. Effect of Spark-Over Voltage

	Crest Lightning-Arrester Discharge Voltage,* Per Cent	Table VII Test
97-kv lightning-arrester valve element alone (no series gap)	114	30
Normal 97-kv lightning arrester	123	1
Impulse spark-over voltage 10 per cent above normal	128	31
Impulse spark-over voltage 20 per cent above normal	132	32

* Per cent of 298-kv front-of-wave spark-over voltage of Thorex *GP-97* lightning arrester

Table III. Effect of Connection and Lead Length

Lightning-Arrester Connection	Crest "Transformer" Voltage,* Per Cent	Table VII Test
At "transformer"	123	1
15-foot separation 10-foot T connection	130	7
50-foot separation 30-foot T connection	147	10
50-foot separation 30-foot V connection	147	13

* Per cent of 298-kv front-of-wave spark-over voltage of Thorex *GP-97* lightning arrester. Note that for these particular tests the V connection showed no benefit over the T connection.

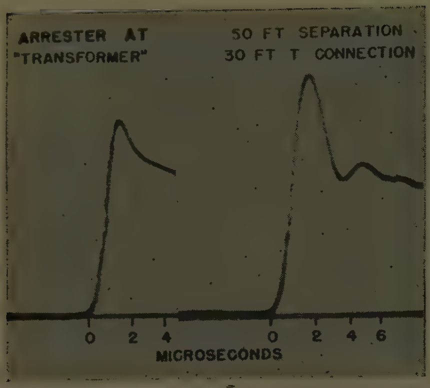


Figure 4. "Transformer" voltage with lightning arrester at the "transformer" and with the lightning arrester 50 feet ahead of the "transformer" with 30-foot down leads

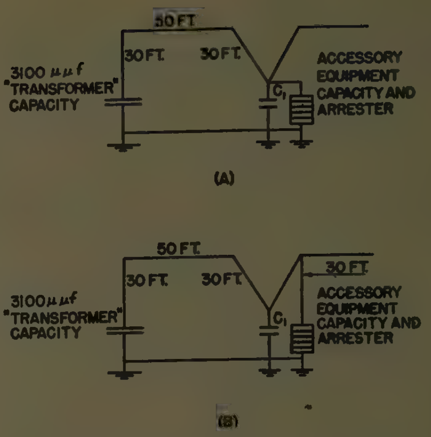


Figure 6. Test circu representing tran former and accesso equipment with ligh ning arrester at a cessory equipmen

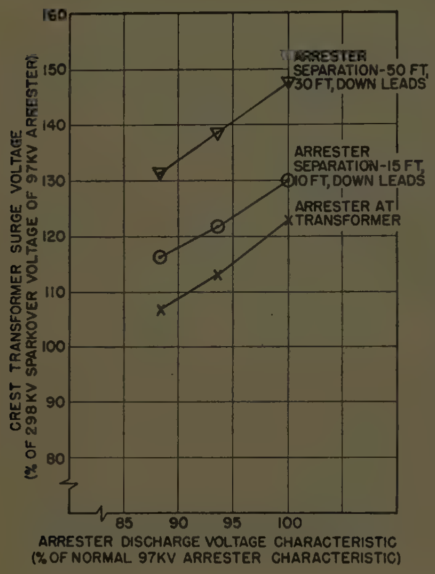


Figure 5. Crest voltage at 3,100-micromicrofarad "transformer" as function of lightning-arrester discharge voltage characteristic for various lightning-arrester separations and lead lengths

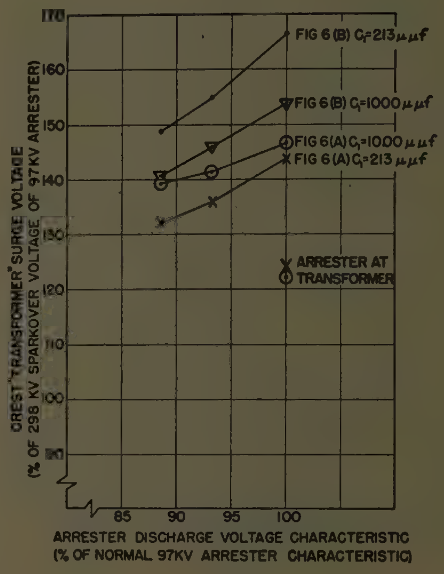


Figure 7. Crest vo age at 3,100-mic microfarad "tra former" as a functi of lightning-arrest discharge volta characteristic lightning arrester accessory equipme

as severe on all forms of transformer insulation as longer waves of the same crest value.[6,7] For major insulation, however, its severity is about as great as for longer waves.

EFFECT OF LOWER DISCHARGE VOLTAGE

Besides the normal 97-kv lightning arrester, special lightning arresters with 7 and 12 per cent of the valve element removed also were tested. These represented 97-kv lightning arresters of 93- and 88-per cent normal discharge voltage characteristic.

When connected directly across the 3,100-micromicrofarad "transformer" their crest voltage was proportional to the valve element as expected. That is, those with partial valve elements allowed crest discharge voltages of about 7 and 13 per cent less than the normal lightning arrester. See tests 1, 2, and 3 of Table VII.

When these special lightning arresters were separated from the "transformer," the crest voltage at the "transformer" quickly exceeded that obtained with a norm lightning arrester connected directly at the "transformer Figure 5 shows the crest voltages at the 3,100-micromicr farad "transformer" as a function of lightning-arres discharge voltage characteristic for different lightnin arrester separations and lead lengths. These are te 1, 2, 3, 7, 8, 9, 10, 11, and 12 of Table VII.

Table IV. Protection With Two Lightning Arresters

Second Lightning-Arrester Location	Crest "Transformer" Voltage,* Per Cent	Table VII Test
None	123	1
At "transformer"	107	4
15-foot separation 10-foot T connection	109	16
50-foot separation 30-foot T connection	114	17

* Per cent of 298-kv front-of-wave spark-over voltage of Thorex *GP-97* lightning arrester.

PROTECTION OF EQUIPMENT

With one lightning arrester at the "transformer" a a second lightning arrester ahead of them, t transformer surge voltage was reduced. However, w the second lightning-arrester separations studied (15 a 50 feet) the transformer lightning arrester still discharg the heavier current.

Most effective use of the second lightning arrester reducing transformer voltage was to use it in parallel w the other lightning arrester at the transformer. This v equivalent to a single lightning arrester of about 13-per c lower discharge voltage in protective ability. Curre through the two parallel lightning arresters were su stantially equal in crest value and wave shape.

Table IV lists crest "transformer" surge voltage wh protected by normal 97-kv lightning arresters, one at "transformer" and the second at the location shown.

Using the circuits of Figure 6, tests were made study the effect of a lightning arrester at the access uipment on the protection of the transformer. In gure 6*A* the lightning arrester was connected directly ross the capacitor. In Figure 6*B* it was connected ahead the capacitor by a 30-foot down lead. Figure 7 shows e crest voltages recorded at the "transformer" for values 213 and 1,000 micromicrofarads for the accessory uipment and a 97-kv lightning arrester of 100, 93, and per cent of normal discharge voltage characteristic. ese are tests 18 through 29 of Table VII. In no case, en with the lightning arrester of 88-per cent discharge ltage characteristic, was the crest "transformer" voltage low as with a normal lightning arrester at the trans- rmer. Figure 8 shows oscillograms of voltage at the ation entrance and "transformer" with accessory equip- ent capacitance of 1,000 micromicrofarads.

With the circuit configuration of Figure 9*A* and a rmal 97-kv lightning arrester at the "transformer," the est voltages of Table V were recorded. These voltages, en at the accessory equipment, were all below those own on Figure 7 for the same capacitance and circuit ut with the lightning arresters at the station en- ance. Voltages are apparently the same for either value accessory equipment capacitance. The crest "trans- rmer" voltages from Table V are shown on Figure 7 for mparison. Figure 10 shows oscillograms of voltage at e accessory equipment and "transformer" with ac- essory equipment capacitance of 1,000 micromicrofarads.

With the circuit of Figure 9*B* and normal 97-kv lightning resters at both the "transformer" and accessory equip- ent, the crest voltages shown in Table VI were recorded.

Figure 11 shows oscillograms of voltage at the accessory quipment capacitance and "transformer," with accessory equipment having a capacitance of 1,000 micromicrofarads.

Comparing these voltages with those of Table V shows the benefit obtained in reduction of crest surge voltage by the addition of a lightning arrester at the accessory equipment. Voltages are apparently the same with 213 as with 1,000 micromicrofarads.

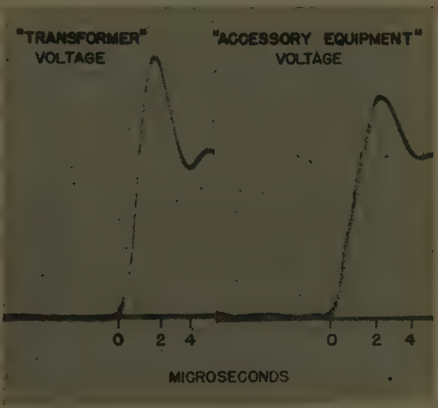
These tests confirm that in the protection of station equipment against incoming surges, lightning arresters should be located near each transformer. Additional lightning arresters at accessory equipment are of considerable benefit, but without lightning arresters at the transformers they may be inadequate.

The voltages considered in this study are crest voltages of relatively short duration, and their relative magnitude may not be an infallible indication of the relative severity of the various voltage surges with regard to all aspects of equipment insulation.[4,7] However, they should indicate the relative protection afforded major insulation by the different lightning arresters and connections studied.

SUMMARY AND CONCLUSIONS

THE DISCHARGE voltage of a lightning arrester connected near apparatus such as a transformer may be higher than that based upon the lightning-arrester characteristic and the magnitude and wave shape of the incoming surge alone. This is because the capacitance of the apparatus adjacent to the lightning arrester is charged to lightning-arrester spark-over voltage and then discharges through the lightning arrester at an initial rate of current rise which may exceed that of the incoming surge, while concurrently the incoming surge front continues to arrive.

Care should be used when applying field data on rate of



gure 8. "Trans-
rmer" and acces-
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acitance voltage
ith lightning ar-
ester at accessory
capacitance

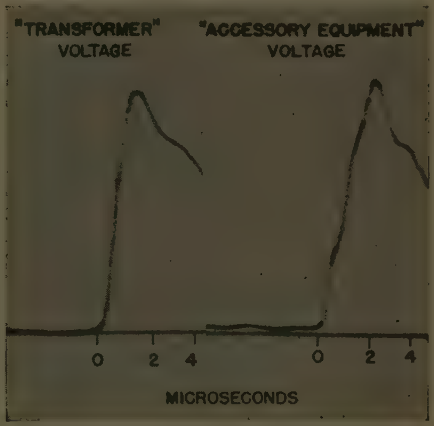
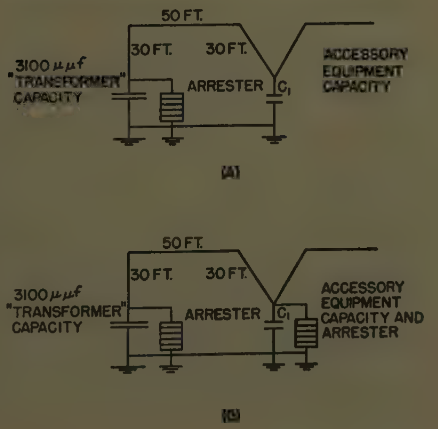


Figure 10. "Transformer" and accessory equipment capacitance voltage with lightning arrester at "transformer"



gure 9. Test cir-
uits representing
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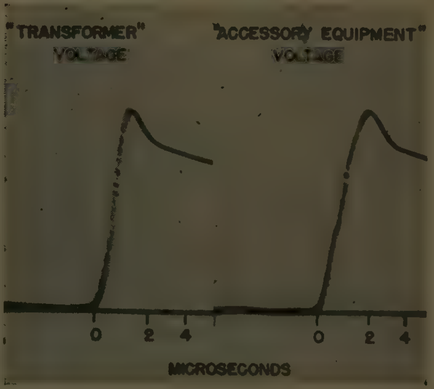

Figure 11. "Transformer" and accessory equipment capacitance voltage with lightning arresters at "transformer" and accessory equipment

Table V. Crest Voltages for Circuit of Figure 9A

	Accessory Equipment Capacitance, Micromicro-farads	Crest Voltage,* Per Cent	Table VII Test
"Transformer" voltage	213	122	5
Accessory equipment capacitance voltage	213	125	5
"Transformer" voltage	1,000	121	6
Accessory equipment capacitance voltage	1,000	128	6

* Per cent of 298-kv front-of-wave spark-over voltage of Thorex *GP-97* lightning arrester.

Table VI. Crest Voltages for Circuit of Figure 9B

	Accessory Equipment Capacitance, Micromicro-farads	Crest Voltage,* Per Cent	Table Test
"Transformer" voltage	213	113	33
Accessory equipment capacitance voltage	213	100	33
"Transformer" voltage	1,000	111	34
Accessory equipment capacitance voltage	1,000	99	34

* Per cent of 298-kv front-of-wave spark-over voltage of Thorex *GP-97* lightning arres

Table VII. Crest Voltage at "Transformer" for Various Test Conditions

Test	Lightning-Arrester Location	Type of 97-Kv Lightning Arrester	Accessory** Equipment Capacitance, Micromicro-farads	Crest "Transforme Voltage*
1	At "transformer"	Normal	0	123
2	At "transformer"	93% normal discharge voltage	0	113
3	At "transformer"	88% normal discharge voltage	0	107
4	2 at "transformer"	Both normal	0	107
5	At "transformer"	Normal	213	122
6	At "transformer"	Normal	1,000	121
7	15-foot separation—10-foot T connection	Normal	0	130
8	15-foot separation—10-foot T connection	93% normal discharge voltage	0	122
9	15-foot separation—10-foot T connection	88% normal discharge voltage	0	117
10	50-foot separation—30-foot T connection	Normal	0	147
11	50-foot separation—30-foot T connection	93% normal discharge voltage	0	138
12	50-foot separation—30-foot T connection	88% normal discharge voltage	0	131
13	50-foot separation—30-foot V connection	Normal	0	147
14	50-foot separation—30-foot V connection	93% normal discharge voltage	0	135
15	50-foot separation—30-foot V connection	88% normal discharge voltage	0	131
16	At "transformer" and 15-foot separation—10-foot T connection	Both normal	0	109
17	At "transformer" and 50-foot separation—30-foot T connection	Both normal	0	114
18	At accessory equipment capacitance	Normal	213	144
19	At accessory equipment capacitance	93% normal discharge voltage	213	136
20	At accessory equipment capacitance	88% normal discharge voltage	213	132
21	At accessory equipment capacitance	Normal	1,000	147
22	At accessory equipment capacitance	93% normal discharge voltage	1,000	141
23	At accessory equipment capacitance	88% normal discharge voltage	1,000	139
24	Ahead of accessory equipment capacitance—30-foot down lead	Normal	213	168
25	Ahead of accessory equipment capacitance—30-foot down lead	93% normal discharge voltage	213	154
26	Ahead of accessory equipment capacitance—30-foot down lead	88% normal discharge voltage	213	149
27	Ahead of accessory equipment capacitance—30-foot down lead	Normal	1,000	153
28	Ahead of accessory equipment capacitance—30-foot down lead	93% normal discharge voltage	1,000	146
29	Ahead of accessory equipment capacitance—30-foot down lead	88% normal discharge voltage	1,000	140
30	At "transformer"	Normal valve element alone	0	114
31	At "transformer"	110% normal sparkover voltage	0	128
32	At "transformer"	120% normal sparkover voltage	0	132
33	At "transformer" and accessory equipment capacitance	Both normal	213	113
34	At "transformer" and accessory equipment capacitance	Both normal	1,000	111

* Per cent of 298-kv front-of-wave spark-over voltage of 97-kv lightning arrester.

** 50 feet ahead of "transformer" with 30-foot V connection.

current rise through lightning arresters in stations. If the data were obtained from lightning arresters mounted directly adjacent to transformers, it would not be correct to use these rates of current rise in analytical or miniature system studies involving separation of the lightning arrester and transformer.

Low lightning-arrester impulse spark-over voltage is important because it controls the voltage to which the capacitance of the connected apparatus is charged before lightning-arrester discharge. This influences the maximum lightning-arrester discharge voltage even though this may be higher than the initial spark-over voltage.

Two normal 97-kv lightning arresters in parallel were the equivalent of one lightning arrester of 87 per cent normal discharge voltage characteristic during these tests. See Table VII, tests 1 and 4. Currents of the parallel lightning arresters divided about equally.

Two parallel lightning arresters at the transformer resulted in lower crest voltage at the transformer than with one at the transformer and one ahead of the transformer. See Table VII, tests 1, 16, and 17.

As others have shown,[2–6] distance between the lightning arrester and protected apparatus adds to the crest sur voltage at the apparatus.

In protecting both transformer and accessory equipme an additional lightning arrester at the accessory equipme is of benefit in reducing the voltage at both, providing lightning arrester is already located at the transform When this is so, the surge current and voltage are high at the transformer than at the accessory equipment.

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Induction Method for Measuring Fluid Flow

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J. H. CHADWICK

N A STUDY of "activated tank" ship stabilization, an unusually difficult flowmetering problem was encoun- red. As conventional methods were not adequate it was cessary to resort to an electromagnetic flowmeter.

The method of stabilization under investigation uses a ater-transfer principle. Antiroll forces are created by ifting water from one side of a ship to the other through a ossduct. The water shift is accomplished by a variable- tch propellor pump. In order to study the pump prop- ly, it was necessary to have a fluid flowmeter capable of eeting exacting requirements. It had to

1. Measure fluid velocities linearly in the velocity range 18 feet per second.
2. Measure fluid velocities instantaneously without lase or amplitude distortion in the frequency range of ro to five cycles per second.
3. Respond to velocity; not to static or dynamic pressure.
4. Present the data obtained to be recorded simultane- usly with information on pump blade angle, and so forth, allow measurement of the pump characteristics.
5. Not disturb appreciably the flow in the duct in hich the velocity is being measured.
6. Be as inexpensive and simple as possible in con- ruction, and reliable in operation.

Anyone at all familiar with hydraulics will recognize the verity of these specifications. The more standard meth- ds, using paddles, propellors, vanes, Pitot tubes, or pres- re pickups, can be eliminated almost immediately. Most these fail to meet several of the requirements. There is, owever, an electromagnetic induction method for measur- g fluid velocity which is linear, instantaneous in response, nsitive, and reasonably stable. The method itself is old, ating back, in fact, to Faraday,[1] but it has been little used ntil recently. A study of basic patents by Kolin[2] *et al*, and e excellent treatment by Thurlemann,[3] led to the con- usion that this method might do the job.

The operating principle of the meter is simply generator ction—Faraday's law of induction. A magnetic field in- uces voltage in a fluid flowing through it ($E=\mathbf{v}\times\mathbf{B}$), and is voltage may be detected by electrodes placed at right ngles to both the flow and the field lines. The magnetic eld in this case was established by two powerful permanent dar magnetron-type magnets. The walls of the duct were placed by plastic in the metering section to avoid at- nuating the induced voltages and to avoid shielding the uid from the field. Flow in the duct was at right gles to a plane bisecting the bodies of the two magnets.

Several important practical considerations required study. One of the most critical was the question of polarization. If both the magnetic field and the fluid flow are unidirectional, the voltage and hence current flow also will be unidirectional. This tends to build up unequal bias voltages on the electrodes. The effect of polarization naturally will be reduced if either the field or the flow is alternating. In this case the flow was alternating, and although the fundamental frequencies of this system were below one-half cycle per second, it was concluded that the rates of flow reversal would still be fast compared to the chemical polarization processes.

The question of nonlinearity due to change of velocity distribution across the section with Reynold's number was considered. Thurlemann[3] has shown that the change of velocity distribution tends to be self-canceling, and in fact has no effect in the ideal case of constant magnetic field across the section. Calculation indicated that less than two per cent nonlinearity need be expected in this case.

Hum pickup and other noise voltages were avoided in so far as possible by careful construction and shielding. The residual bias voltages, due to constant polarization, were eliminated by an adjustable bias-bucking circuit.

The signal from the electrodes was amplified by a chopper-type d-c amplifier which, in turn, drove one channel of a Brush pen recorder. The chopper-type amplifier gave maximum stability, but naturally limited the frequency response of the over-all system. As the chopper operated on 60 cycles, the system was able to pass a signal of up to six cycles per second without excessive distortion.

Fields tests of the flowmeter system established the characteristics as follows:

Linearity—linear to within experimental error of about 1 per cent.

Frequency Response—0 to 6 cycles per second without excessive distortion.

Sensitivity—1.2 millivolts per foot per second at the electrodes. 200 volts per foot per second at the pen recorder.

Noise—equivalent to about 0.01 foot per second flow.

Drift—0.05 millivolt per minute at 0.3 cycle per second, and 0.10 millivolt per minute at 0.03 cycle per second (at the electrodes).

These characteristics were completely satisfactory for study of the pump, and hence the particular problem which instigated the work was solved. For more general usage it might be desirable to have less drift.

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3. Methode zur electrischen Geschwindigkeitmessung von Flussigkeiten, **B. Thurlemann.** *Helvetica Physica Acta* (Basel, Switzerland), volume 14, 1941, pages 383–419.

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An Electronic Power Source for Large D-C Contact Testing

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A POWER SOURCE for a-c testing for currents up to 10,000 amperes is reasonably easy to obtain since it requires only a suitable transformer and a line supplying an adequate amount of power. No rotating equipment is necessary. If direct current is required, rotating equipment involving perhaps a 1,000-kw generator would be required to deliver 10,000 amperes at 250 volts. A larger set would be required for currents at 600 volts and 750 volts. Sometimes special motor-generator sets are used having a high inertia, special windings, and an undersize driving motor to deliver the momentary power needed for contact testing. Such equipment is expensive, requires a large amount of space, and is not flexible as far as output voltage is concerned.

This article describes a solution to this power requirement by using electronic tubes.

REQUIREMENTS

A FIRST CONSIDERATION is the service requirement. The primary requirement is providing momentary power as required by the standard system of contact testing involving 50 repeated operations at 10-second intervals momentarily closing and opening the circuit, a test which is sometimes referred to as the 50-OCO test. A secondary requirement is the use of the power source for continuous loads. Major voltage requirements involve 250-volt systems with a lesser requirement at voltages near 600 volts.

A scheme for providing power electronically for large d-c contact testing has been devised. This power source provides characteristics which are quite acceptable for testing up to 10,000 amperes at 250 volts; it is less expensive than rotating equipment, has a voltage range from 250 to 750 volts, and takes less space than rotating equipment.

With these requirements in mind the welder ignitron tube in size D was considered particularly well adapted since it is designed for use on welding cycles usually more severe than those demanded in this application. It has a higher intermittent capacity and a lower cost than the corresponding rectifier tube. It is more susceptible to flash backs than the rectifier tube because of the omission of the shielding in the tube.

This susceptibility to flash backs leads to the use of impedance in the feeder circuit which limits the current to a value less than the published maximum instantaneous values for the size D ignitron tube. This value is approximately 14,000 amperes. In this particular installation this impe ance is the combined transformer and feeder line impedan without the use of any additional reactors or resistors in th circuit.

DESCRIPTION

THE RECTIFIER is shown in Figure 1. A diagram of th manner in which the rectifier is connected to the pow system and the test device is shown in Figure 2. A sch matic diagram of the internal connections of the rectifi power and igniter circuits is shown in Figure 3 and th rectifier control circuit in Figure 4.

Simplification of the firing circuit was obtained by usi the load current to fire the ignitors. This arrangement al eliminated the problem of co-ordinating the phase shift one voltage source with respect to the other when hig currents were drawn from the transformer. In order make this scheme successful, it is necessary to connect a loa resistor to the rectifier so that it always draws sufficie current to cause the ignitrons to fire. This resistor is r connectable by a series-para lel switch loading the rect fier to about 100 amperes 250 volts and to about 5 amperes at 600 volts.

For cooling, all six tub were connected in series the city water supply with flow switch at the outlet of th last tube arranged to inte lock the circuit so that th rectifier could not be operat unless the water was turned on. No attempt was mad to recirculate the water through the jackets.

A sequence control is provided, as shown in Figure 4, sequence the rectifier by establishing direct current throug the load resistor just prior to the closing of the contacts of th device being tested. A timer then opens the device aft which the operator releases the push button to de-energi the rectifier. This provides two desirable features: saves power during the off period and it gives the operat finger-tip control of the current should the test contact fail to open the circuit.

The use of the manual button to start each cycle of co tactor operation has been chosen purposely to obtain ra dom operation of the contactor with respect to the ripp voltage. Automatic timing in some cases has a tenden to cause the contactor being tested to be cycled closed the same point of the cycle for each operation. Such arrangement is considered to be an unfair test, althoug

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Full text of paper 51-51, "An Electronic Power Source for Large D-C Contact Testing," recommended by the AIEE Committee on Industrial Control and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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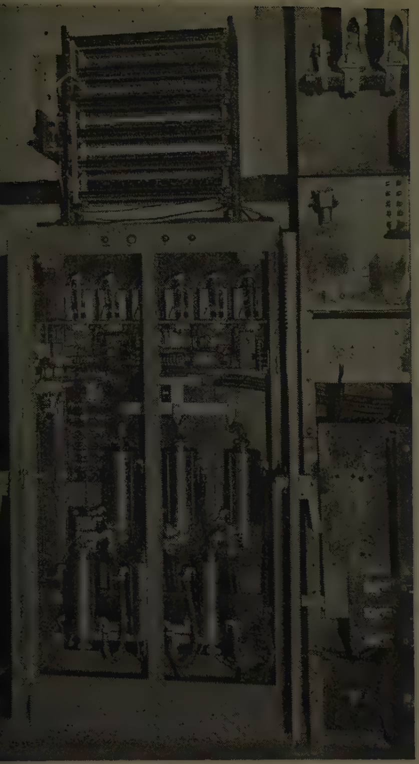


Figure 1. This illustration shows the rectifier installed for use

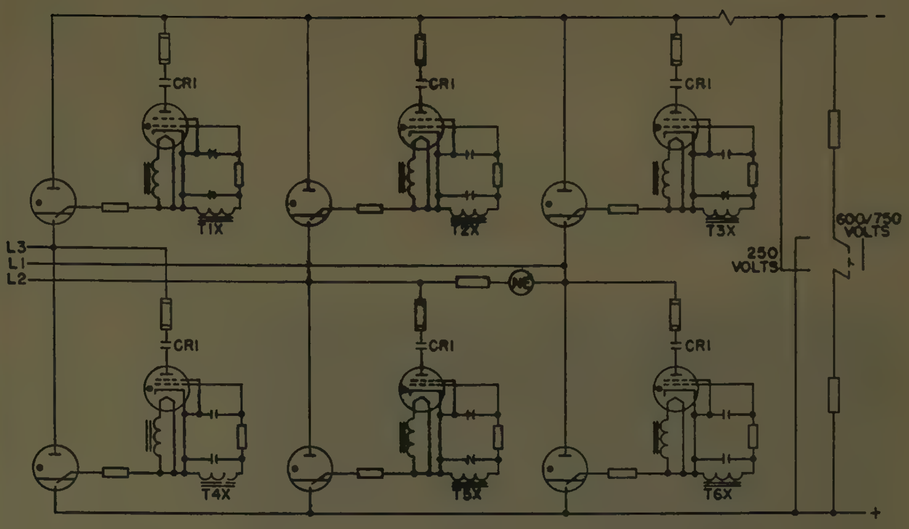
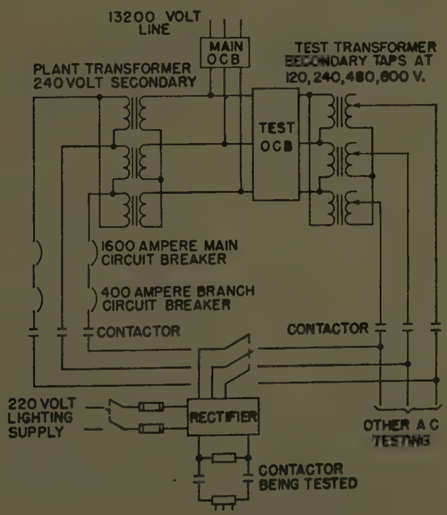


Figure 3. Diagram of rectifier power and igniter circuits

ro phase back is used in the rectifier the ripple voltage is ore or less insignificant. Reference to the oscillogram, gure 5, will indicate the proportions of ripple voltage enuntered.

It will be noted that six ignitron tubes are used giving the uivalent of 6-phase operation but that only three connecons are brought out from the transformer. While this as a necessary part of this particular installation because e transformer was provided with only the three external onnections for each set of voltages, it also provides addional limitations to the current in the case of flash backs ecause two tubes are always connected in series for coniction.

Voltage taps used on the transformer input are at 240, 30, and 600 volts. These taps give voltages on the d-c de of approximately 275, 600, and 750 volts. Another p available on the transformer at 120 volts could not be used because proper ignition of the ignitron does not occur at this low voltage. An attempt to use it caused the 3-ampere fuses to blow in the ignitor circuits. For voltages below 275 volts the phase-back control may be used. Phase-back control is not considered satisfactory for rupture tests since the ripple voltage becomes disproportionate and aids the device being tested in the interruption of the current. However, it is useful in supplying voltages for motors because the additional ripple voltage may be of little consequence.


13200 VOLT LINE
MAIN OCB
PLANT TRANSFORMER 240 VOLT SECONDARY
TEST TRANSFORMER SECONDARY TAPS AT 120, 240, 480, 600 V.
TEST OCB
1600 AMPERE MAIN CIRCUIT BREAKER
400 AMPERE BRANCH CIRCUIT BREAKER
CONTACTOR
CONTACTOR
220 VOLT LIGHTING SUPPLY
RECTIFIER
OTHER A C TESTING
CONTACTOR BEING TESTED

gure 2. Diagram connections to power supply

It is realized that the rectifier is not identical to a gener-

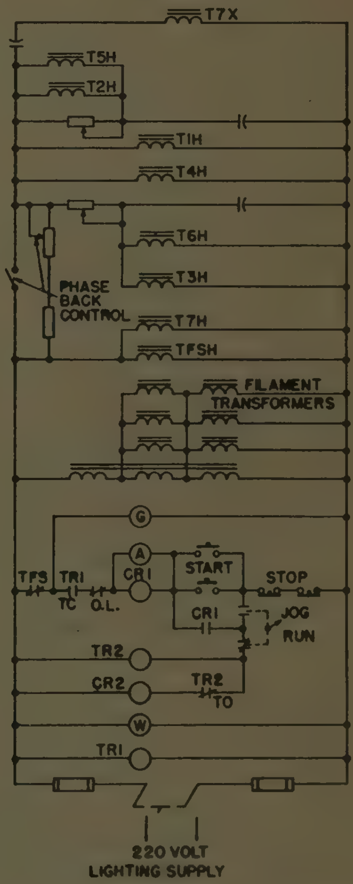


Figure 4. Diagram of the rectifier control circuit

ator because of the difference in the amount of inductance in the system. It will be noted from the oscillogram, however, that the recovery of voltage is fast in the case of the rectifier system.

For test work a fast recovery of voltage usually leads to the earliest breakdown of the equipment which is being tested. However, a fast recovery voltage indicates a small amount of inductance in the circuit and may, therefore, fail to bring out a flashover which might be aggravated by some extra inductance. Up to about 30 amperes a blind-spot check was made on a special 100-ampere contactor. Failure by holding the arc occurred with the rectifier at 270 volts, and with a 25-kw 250-volt d-c generator as the power source, in such a way as to indicate the results cross-check.

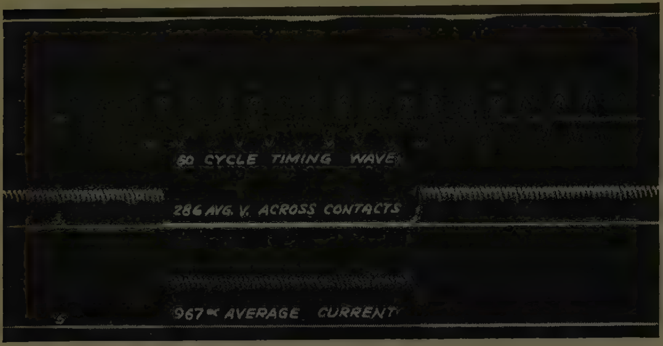


Figure 5. Oscillogram of ripple and recovery voltages

This equipment is limited in capacity by the size of ignitron tube available, since one of the tubes must carry the entire current being drawn from the system at any one instant. Paralleling of tubes is not practical with this arrangement because the scheme does not provide assurance that both tubes in parallel would be fired and carrying current.

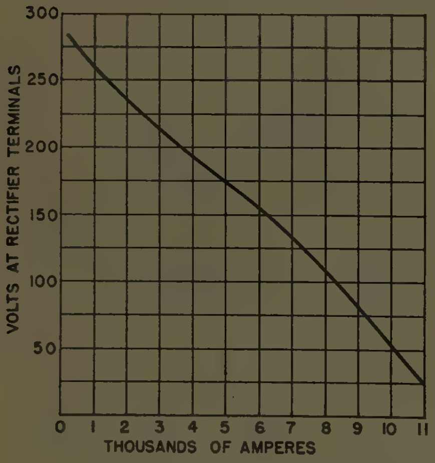


Figure 6. Rectifier terminal voltage plotted against current load

The rectifier terminal voltage plotted against current load is shown in Figure 6. These data do not plot in a straight line. Early effort indicated that this was traceable to errors in obtaining data. Refinement in data closely confirmed the shape of the curve as all data points touch th curve line. While firm conclusions were not reache contributing factors may be capacitance effect at lowe currents and internal resistance in the bus structure a higher currents.

Current and voltage readings are taken by using mete equipped with mechanical stops so that the hand may b preset to just below the anticipated value. The meter han then may move through only a short distance to give a rea sonably accurate reading on a current which flows le than one second. For voltage readings for the high cu rents, an extra contact on control relay *CR1* is used to co nect the voltmeter at the same instant that the load is co nected.

This permits the use of a meter having a lower ful scale reading for the lower voltage readings.

The regulation of this rectifier, together with the induc ance and recovery voltage characteristics, may or may n make it typical as a source of test power. Since there is trend in the industry to use rectifiers as power supply, may become increasingly important to use a rectifier as source of power when testing devices which ultimately ma be applied where rectifiers are used as a d-c source.

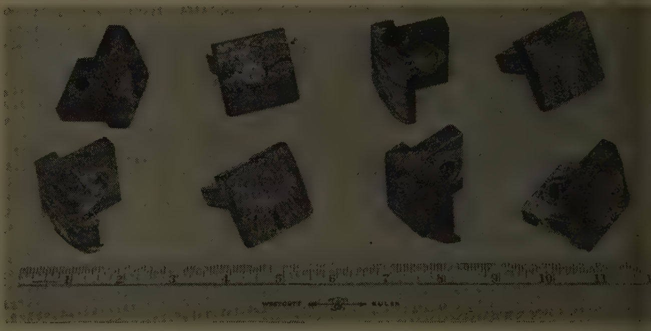


Figure 7. Contacts that have undergone rupture tests

Figure 7 shows contacts that have undergone ruptu tests using power from this unit. Note the separation facing material on contacts in the upper left and lower righ Erosion of the backing material shows in the lower se Contacts at the upper right are a copper alloy enduri successfully over 10,000 amperes at 275 volts.

The floor space which is occupied by this equipme measures 41 inches wide by 21 inches deep. The cabi proper measures 80 inches high. An additional 30 inch in height is used to mount the minimum load resist Water connections are brought in from the left and feed from the right.

CONCLUSIONS

In summary, we may say that this scheme of providing power provides characteristics which are quite acce able for testing up to 10,000 amperes at 250 volts; has a greatly reduced cost when compared to rotati equipment; it is quite flexible as far as voltage outpu concerned in the range of 250 to 750 volts; and it occupie cubicle small by comparison with rotating equipment.

The Trend Toward Instant Starting of Fluorescent Lamps

J. H. CAMPBELL

WHEN FLUORESCENT LAMPS were first introduced 12 years ago, the lighting profession was provided with new and advantageous tools for the extenon of lighting levels. Increased efficiency, better light stribution, controllable color, and more comfortable ightness ratios are ever-present advantages of the new ght source. The acceptance was immediate and great otwithstanding the relatively higher initial cost and comlexity compared to filament lighting. Some idea of the conomic importance of fluoescent auxiliaries can be ained by the fact that these omponents make up from) to 50 per cent of the total ost of the luminaire.

Instant and quick-start circuits now on the market for use with fluorescent lamps include the series or sequence type as well as high-frequency circuits. New designs may lead to smaller ballasts or to a self-starting lamp which will start instantly with present switch-start fixtures.

Improvements were raplly made in circuits, lampolders, starters, and ballasts s new lamp types were anounced. Early circuits consisted of a series reactor and a arting switch for the small lamps and an autotransformer, eries reactor, and starting switch for the higher voltage mps such as the 30- and 40-watt lamps. The need for igh power factor resulted in the design of capacitors to be laced across the service line, individual capacitors incorpoated in each ballast, and the split-phase lead-lag ballast. he evolution of starters took place, rapidly changing in rder from manual to magnetic to thermal to glow. In witch-start circuits, the 2-contact glow switch is widely acepted because of its low cost, simlicity, and short recycling time. he manual and thermal switch are esirable for some applications.

THE NEED FOR INSTANT START

N SPITE OF the many improvements in starters it became obvious that moving part for each lamp reulted in maintenance which was oth annoying and expensive when pplied to large installations. The rst instant-start circuit was deeloped for the 40-watt lamp when athodes were designed to take high-oltage starting. Accordingly, when ne slimline lamps were developed, nstant-start circuits were designed to start and operate them. Although it was just as desirable to provide instant-start ballasts for small lamps, economic considerations impeded the acceptance until recently when the "trigger-start" or automatic-preheat circuits were announced.

LAMP CHARACTERISTICS

IT IS NOT within the scope of this article to discuss the many fluorescent lamp characteristics related to gaseous discharge phenomena. For a more detailed discussion the reader may wish to refer to books on the subject.[1–3] However, to clarify discussion, it may be well to review some lamp characteristics which dictate circuit and ballast design.

Referring to Figure 1, when lamp electrodes are preheated by means of a series starting switch, thermionic emission takes place. The argon or krypton starting gas and mercury vapor become ionized because of the collision of electrons with gas molecules. Ionization reduces the impedance of the arc path, thus preparing the lamp for starting. When the switch opens, the voltage of the line and an inductive surge voltage appear across lamp electrodes with enough magnitude to initiate the main arc. When surge is insufficient, the starting cycle must be repeated, thus delaying starting operation. Once started, the lamp exhibits a

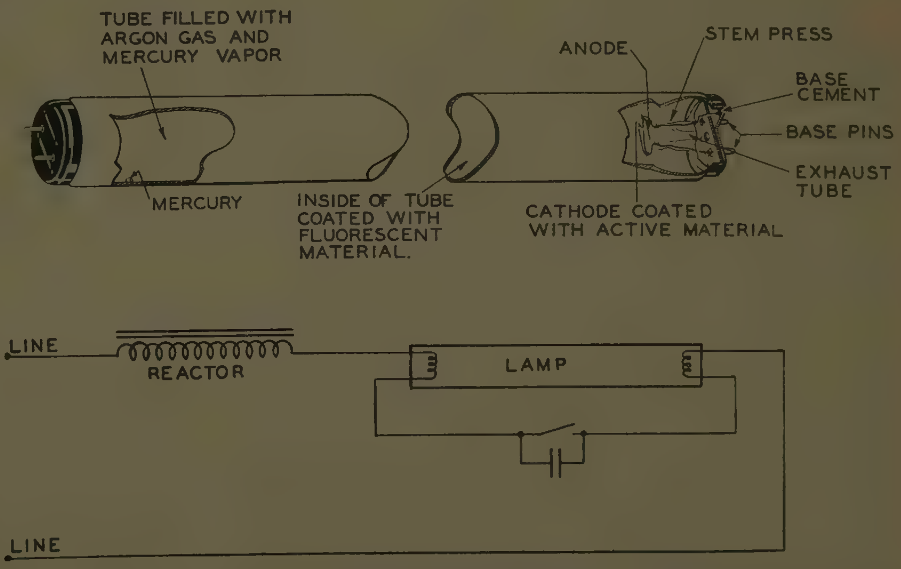

TUBE FILLED WITH ARGON GAS AND MERCURY VAPOR
ANODE
STEM PRESS
BASE CEMENT
BASE PINS
EXHAUST TUBE
MERCURY
INSIDE OF TUBE COATED WITH FLUORESCENT MATERIAL.
CATHODE COATED WITH ACTIVE MATERIAL
LINE
REACTOR
LAMP
LINE

Figure 1. A typical fluorescent lamp with starting and operating circuit

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sentially full text of a paper presented at the IEE Cleveland Chapter Meeting, January 18, 1951.

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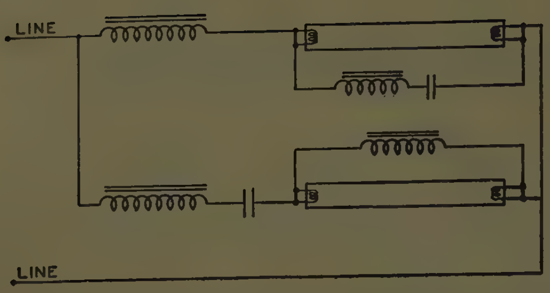


Figure 2 (left). An early 60-cycle resonant circuit for instant start

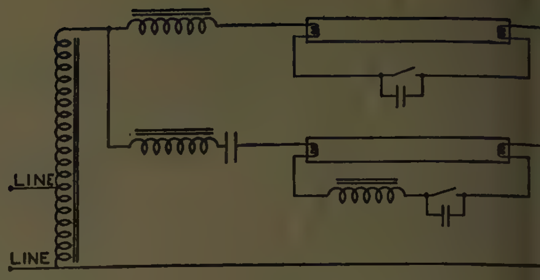


Figure 3 (right). Conventional split-phase switch-start circuit

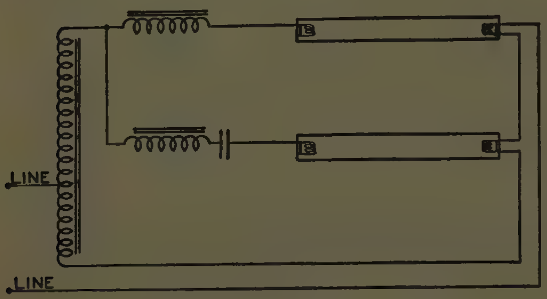


Figure 4 (left). The multiple instant-start circuit

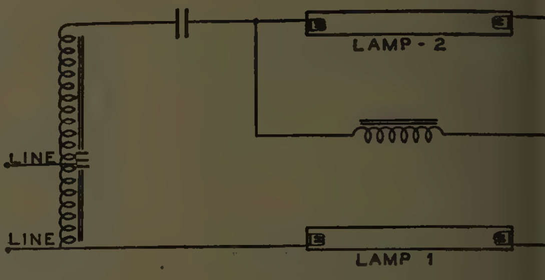


Figure 5 (right). Fundamental sequence-start series circuit

negative resistance characteristic so the current is limited only by the predetermined impedance of the series reactor.

A surge voltage in excess of 1,000 volts generally is produced by the reactor at the opening of the starting switch. Consequently, if the starting switch is eliminated by means of a preheat transformer as in the case of the trigger-start circuit, applied voltage must be increased to make up for the lack of surge voltage.

Fluorescent lamps can be started without electrode preheat by increasing the applied voltage until free electrons are accelerated sufficiently to produce a cascade of ionization with subsequent current conduction and eventual arc discharge.

MULTIPLE INSTANT-START CIRCUITS

PARADOXICALLY, one of the first methods for starting fluorescent lamps was by means of a circuit without moving parts. The early instant-start circuits were of the resonant type or high-reactance transformers with a secondary voltage sufficient to start the lamp. However, at that time, the lamp electrodes were not capable of withstanding the voltage applied and the ballast was large and expensive. Figure 2 shows a typical split-phase resonant-start circuit.

In designing an instant- or fast-start circuit, the lamp characteristics previously described must be considered first. The fluorescent lamp requires a starting voltage of from $2^{1}/_{2}$ to $4^{1}/_{2}$ times its operating potential, depending on lamp dimensions and whether cathodes are preheated or initially cold. When inductive reactance is used as a ballast, the applied voltage is generally twice the lamp operating voltage for proper lamp current regulation. The absorption of this voltage during operation, whether required for lamp starting or lamp current regulation, limits the conventional ballast to a given size and efficiency.

The first commercially acceptable instant-start ballast was made by redesigning the starter-type split-phase ballast, Figure 3, so that adequate voltage was impressed between lamp electrodes to provide starting without preheat. The instant-start split-phase circuit (Figure 4) applies in general to the 40-watt and slimline lamps. This circuit provides high power factor for the transformer primary by combining in the secondary a leading and lagging power facto circuit.

Before any high-voltage instant-start ballasts could b placed on the market, it was necessary to develop a ne lamp electrode capable of withstanding the bombardmen type of electrode heating. Once this lamp had been developed, the circuit and ballast designers could proceed wit the thought of providing the required starting voltage in th most economical way.

SEQUENCE START SERIES CIRCUITS

THE STANDARD split-phase instant-start circuit, Figure 4 met lamp requirements but had the disadvantage c considerably greater weight, size, cost, and loss compare with ballasts employing starters. Therefore, a method wa devised to reduce the volt-amperes in the ballast by mean of applying the starting voltage first to one lamp and then t the other. This design is known as the sequence-start serie operating circuit. Early design work on this method c starting resulted in a preheat circuit for 100-watt lamp which saved 50 per cent of ballast weight, size, cost, an loss.[4] These ballasts employing starters were used to som extent during World War II in large industrial plants an have since been revised for use with the 85-watt lamp. Th application of sequence-starting to eliminate switches provides similar advantages when compared to multiple instant-start circuits.

Figure 5 shows the fundamental sequence-start serie operating instant-start circuit. The transformer provid the same open-circuit voltage as that of the convention split-phase circuit. Normally, almost double this voltag would be required to start two lamps in series. Howeve by means of the shunt circuit, lamp 1 receives full voltag and starts first, the current taken by lamp 1 passes throug the small linear reactor and series capacitor producing near resonant voltage to start lamp 2. After the lamp have started, the ballast absorbs only the difference of th ombined lamp voltage and the applied voltage. Com-ared to the conventional lead-lag circuit shown in Figure , it is seen easily that the ballast of the series circuit operates t a lower volt-ampere rating. Therefore, a considerable eduction in size, weight, and loss is realized. High power ctor is obtained by operating the transformer primary at a igh flux density or introducing a series air gap in the pri-ary flux path.

Figure 6 illustrates one of the sequence-starting series-perating circuits now on the market. The ballast em-loying this circuit is known simply as the series-type ballast. n this arrangement, coil *A* is the primary and coil *B* the econdary of the power transformer. Coil *C* is a high-oltage low-current winding which provides starting voltage or lamp 1. With lamp 1 conducting current, lamp 2 re-eives the vector sum of the voltage drops of all three coils. After starting, the lamps operate in series.)

Figure 7 illustrates the vector diagrams of the sequence-tarting series-operating circuit shown in Figure 6. Dia-ram *A* shows the voltages produced in the ballast before ither lamp starts. The voltage of coil *C* is sufficient to start amp 1. Diagram *B* shows the vector relationship of the omponents after lamp 1 starts. The voltages of coils *A*, *B*, and *C* add up to produce a voltage sufficient to start lamp 2. Diagram *C* illustrates the vector relationships existing luring operation of both lamps.

Lamp performance characteristics such as life and lumen naintenance can be predicted with reasonable accuracy for tarter or automatic preheat circuits. This is the result of ears of experience in which normal life tests have been con-lucted and correlating evidence obtained by varying pre-ieat current, preheat time, and starting voltage. Compre-iensive specifications covering ballast designs therefore have een written to cover these conventional circuits. Subsequently, the same type of information was gathered for in-tant-start multiple circuits.

The time required to make these tests for each change in amp and ballast design is quite long considering that there s not as yet a satisfactory method for accelerating a fluores-ent lamp life test. Very often, over a year is required to est the effect on life and lumen maintenance of a single ariable in circuit or lamp design. The sequence-start eries-type of ballast has not been in existence long enough o predict accurately lamp performance as compared to con-entional ballasts. Tests are further complicated because everal types of sequence-starting series ballasts have been placed on the market in the last two years. Life tests on some early designs of sequence- or series-type ballasts showed about two-thirds lamp life compared to the multiple circuit. Features of the ballast which, in most applications, tend to compensate for the reduction in lamp life are lower initial cost, increased over-all efficiency, and a reduction of critical materials. Some of the differences in the various sequence-start series circuits now being checked for effect on lamp life are: time required to establish the cathode hot spot, starting current waveform, magnitude of current available to start, and the changes in these factors with low and high ambient temperatures. Tests nearing completion on improved ballast designs indicate that specifications now can be written to provide lamps operated on series or sequence ballasts with the same life as now provided by multiple ballasts.

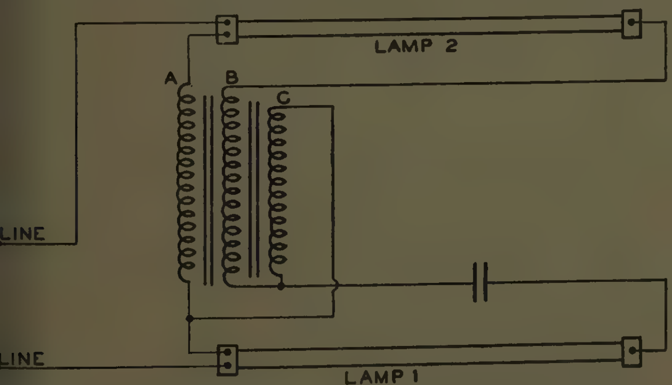
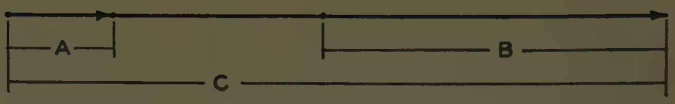
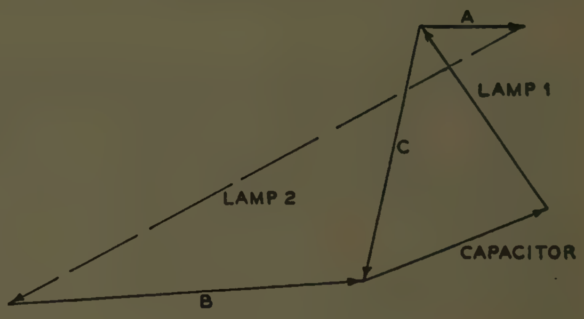


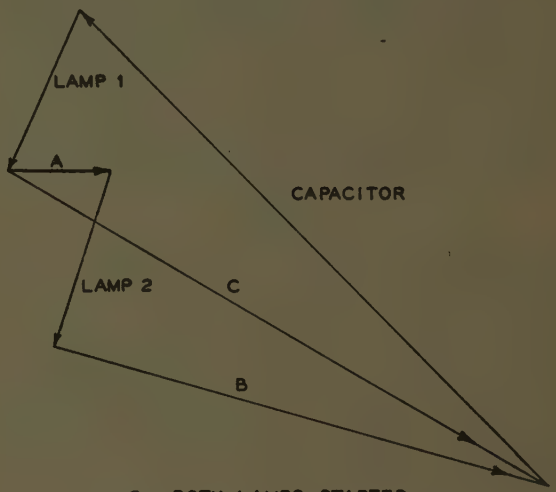
Figure 6. A sequence-start series circuit now on the market



A. NO LOAD



B. LAMP NO. 1 STARTED



C. BOTH LAMPS STARTED

Figure 7. Vector relationships of voltage in the sequence-start series circuit of Figure 6

Table I gives the per cent watts loss, total weight, copper and iron weight, and cost of typical ballasts employing some of the circuits previously discussed. Comparison is based on the multiple ballast of Figure 4 as 100 per cent. Ballasts for use with 40-watt lamps have been chosen because this lamp is the highest production type and available ballasts for operating the 40-watt lamp include all of the circuits shown. It is significant to note that instant-start ballasts of

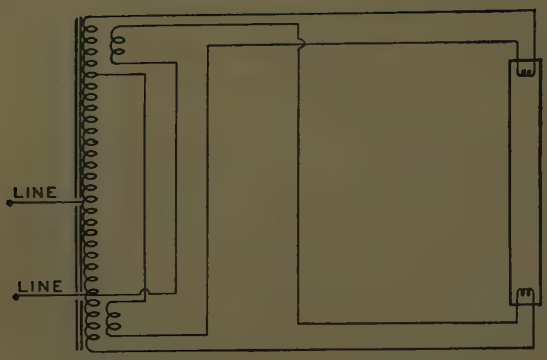


Figure 8 (left). The fast-start or "trigger-start" circuit for bi-pin lamps

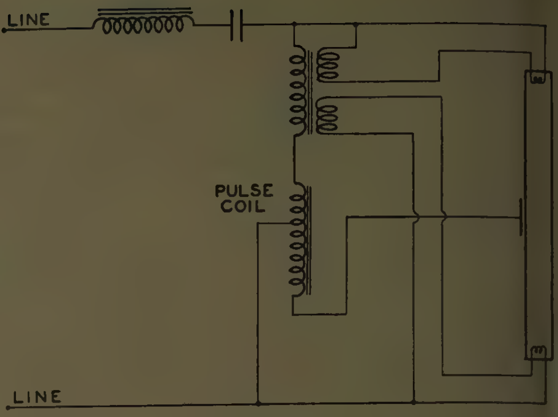


Figure 9 (right). Automatic-pulse coil-starting circuit

the sequence series type are approaching values for the ballasts requiring starters.

The so-called fast-start or trigger-start automatic-preheat circuits eliminate the starter, as shown in Figure 8. The voltage required to start the lamp is somewhat higher than for switch-start, but considerably lower than required to start the lamp by high voltage alone. The use of automatic preheat circuits is limited electrically to lamps having a 2-contact base. Ballasts employing this circuit provide fast starting for low-voltage lamps such as the 14-, 15-, 20-, and 32-watt types.

Table I. Characteristics of Typical Ballasts

	Per Cent Loss	Per Cent Weight	Per Cent Cost	Per Cent Copper	Per Cent Iron
Multiple Instant Start	100	100	100	100	100
Series Instant Start	72	75	75	42	74
Multiple Preheat Start	55	63	50	25	56

POSSIBLE CIRCUITS FOR FUTURE USE

An automatic pulse coil has been designed for ionizing the gas in a fluorescent lamp through external capacitive coupling. Figure 9 illustrates the circuit. The coil produces a low-energy pulse of high voltage each half-cycle of the input-power frequency. The pulse energy is transferred to the lamp by means of a small metallic radiator which can be incorporated as part of the fixture. The primary of the small preheat transformer serves to provide voltage excitation for the primary of the pulse coil. With the lamp fully ionized and the electrodes emitting, the main arc is initiated merely by applying whatever voltage is required to regulate lamp current. Therefore, a minimum-size ballast can be designed. Since starting can be obtained at a voltage close to the lamp operating potential, it is feasible to employ a tungsten-filament lamp as ballast. Current control by means of resistance has advantages such as quiet operation, light weight, and low initial cost, but the disadvantage of a somewhat lower over-all efficiency.

HIGH-FREQUENCY OPERATION

In the trend toward instant starting of fluorescent lamps, many circuits have been devised to accomplish this purpose economically. However, unless radical changes are made in lamp construction, it appears that a minimum size and weight of ballast for 60-cycle power will soon be reached. With this point in mind, a considerable amount of test work has been carried on to determine the advantages of higher frequency operation of fluorescent lamps.[5] Results show a marked reduction in over-all weight of ballasts along with increased lamp and circuit efficiency. For example, when present 40-watt fluorescent lamps are operated at 400 cycles a lightweight low-loss capacitor can be employed as a ballast. Lamp efficiency is increased by 6 per cent while circuit efficiency is raised 20 per cent. Combinations of inductive and capacitive reactance can be used to obtain instant starting and high power factor with less than 50 per cent of the weight of the smallest 60-cycle ballasts. In general applications, many of the advantages of high-frequency operation would be lost, due to the size, weight, and efficiency of commercially available rotating-type frequency converters. However, progress is being made in the development of harmonic generators which do not contain moving parts and can be treated as transformers.[6] High-frequency lighting systems are being used to some extent in aircraft and motor-coach installations where either 400-cycle or variable-frequency power supplies are available.

LAMPS FOR INSTANT START

There are two main approaches to the instant-start problem: (1) the design of circuits and ballasts to start and operate the present lamps, and (2) the design of lamps to start at lower voltages, so smaller and lower cost ballasts can be designed. A radical change in the design of the lamp requires very careful electrical analysis as well as judicious economic consideration because of the high production and the necessity for meeting previous commitments regarding life and lumen maintenance. However, such a method of attack is not only feasible but may become advisable if progress is to be made in improving the over-all combination of the light source and the equipment needed to operate it.

There are many approaches in the process of redesigning the lamp for low-voltage starting, and no doubt a combination of several will finally result.

Following are some of the ways by which lamps can be made to start at lower voltages:

1. Lower starting gas pressure.
2. Larger diameter lamps.
3. Inside stripe connected to one electrode.
4. Auxiliary electrodes.
5. Inside transparent conducting coating.

6. Activated starting electrodes with inside transparent coating or equivalent external circuit.

It is not within the scope of this article to discuss all of hese methods in detail. However, it will be well to point but some of the known limitations of a few departures from tandard practice.

1. If the starting gas pressure is reduced, the voltage required to start is also reduced. This method alone will not bring starting voltage low enough to justify the change. Reduced pressure also results in increased bombardment of the electrodes during operation and life and lumen maintenance becomes relatively poor.

2. Increasing the diameter of the lamp while maintaining standard pressure and current loading probably will not reduce starting voltage sufficiently to justify the added expense of the larger bulb, fixture, and lampholders.

3. An inside conducting stripe connected to one lamp terminal results in a lamp which will start at low voltage since line potential is applied at a fixed position in the ionizing medium for the entire length of the lamp (Figure 10). If, in addition, a somewhat lower starting gas pressure is employed, lamps can be made to start at a voltage approaching that of the switch start system. A special material which will not contaminate the lamp, preferably fired onto the inside glass surface, must be used. The glass stem at one end must be fitted with a connector in order to make permanent contact with the conducting stripe. Compared to present manufacturing methods using high-speed machines, production cost of this lamp may be considerably higher. Fluorescent lamps of the type shown in Figure 10 are in use abroad where most distribution systems provide 240 volts. Instant starting is obtained with filament lamp ballasts which are operated at rated voltage and therefore contribute to the over-all light output of the fixture. The lamp and circuit efficiency is considerably lower when compared with the reactor ballast system. However, the filament lamp ballast has a significant advantage in Europe where copper and iron are in very short supply.

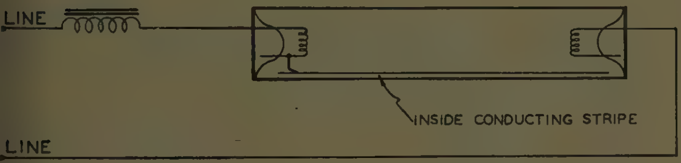


Figure 10. Fluorescent lamp design employing an inside conducting stripe connected to one electrode

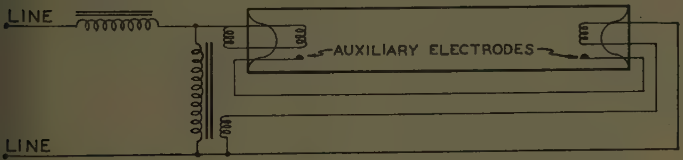


Figure 11. Fluorescent lamp design using auxiliary electrodes

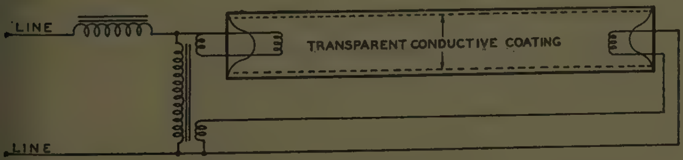


Figure 12. Fluorescent lamp design with inside transparent conductive coating

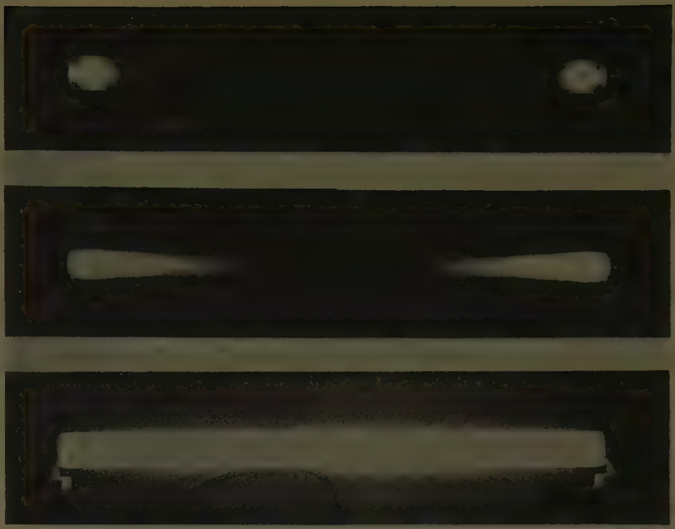


Figure 13. Starting sequence of lamp with inside transparent conducting coating. Top—glow discharge between electrodes and bulb wall; middle—extension of ionization produced by potential gradient along bulb wall; bottom—full ionization produces main arc discharge between electrodes

4. Auxiliary electrodes can be made to produce starting voltages close to the lamp operating drop. Each electrode has an unactivated starting electrode insulated from it by means of the glass stem. The two starting electrodes then are connected in series externally. When line voltage is applied, a glow discharge takes place between each main electrode and the starting auxiliary. The glow discharge current is relatively small, being of the order of one milliampere. Ionization takes place in the vicinity of the electrodes, lowering the impedance of the main arc path. This scheme works well on all straight lamps but since photoionization is partly responsible for starting, curved lamps show little reduction in starting voltage. While such a lamp might be manufactured conveniently on automatic machinery, it requires a 3-lead stem and a 3-contact base and lampholder. Figure 11 illustrates this type of construction.

5. If the glass bulb of the lamp is completely coated on the inside surface with a transparent conductive material, a lamp can be made to start within 30 per cent of its operating potential provided a small amount of preheat current is supplied to the electrodes (Figure 12). Standard electrodes may be used without any connection to the conductive coating. Resistance of the coating is not critical since low-voltage starting may be accomplished with a range of 2,000 to 1,000,000 ohms. When line voltage is applied, an auxiliary discharge takes place between each electrode and the adjacent conductive coating (top, Figure 13). Since the discharge current flows through the conductive coating, a potential gradient is set up along the bulb wall. When the potential at any one point reaches ionizing voltage, the glow discharge is extended from each

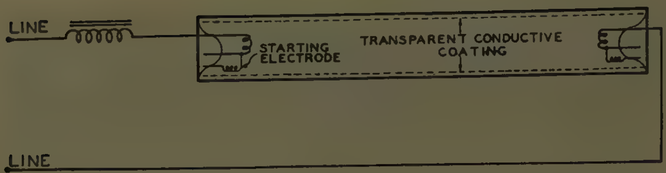


Figure 14. Self-starting lamp design employing starting electrodes and transparent conductive coating

electrode in the form of a cone (middle, Figure 13). At the moment both cones meet, the lamp becomes completely ionized and the main arc strikes (bottom, Figure 13).

Tests to date indicate some contamination of one type of phosphor as a result of the conductive coating. Further analysis will be needed to determine how this may be overcome.

The lamp designs of Figures 11 and 12 depend upon transformer application of low-temperature preheat. Therefore, both are limited to lamps with double contact bases.

6. The lamp design illustrated in Figure 14 shows possibilities for application to any lamp whether bi-pin or single contact. The bulb of the lamp is coated as previously described, but with sufficient quantity to produce a resistance of low order, 2,000 to 3,000 ohms. When line voltage is applied, glow discharge takes place between the activated starting electrode and adjacent conductive coating. Due to the low resistance of the bulb wall path, the current rises to a value sufficient to heat the starting electrode to emissive temperature. As a preliminary to initiation of the main arc, glow discharge takes place, as illustrated in Figure 13. The main arc then occurs between starting electrodes, and the higher value of current passe through the main electrode bringing it up to emissive temperature. The arc then transfers to the main electrode due to the lower resistance and higher potential offered a this point. Some lamps, particularly the low-voltage types may require an internal connection from one starting electrode to the conductive coating in order to reduce the voltage required to initiate the glow discharge. It is obvious that if such a lamp can be made in high-production quantities, it will serve a twofold need. First, it will provide for low-cost ballast designs to take advantage of the low starting voltage, and second, it will provide a possible replacement for preheat-type lamps and provide instan starting in present installations by merely removing the starters.

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The Canadian Approvals Laboratories

G. MOES
MEMBER AIEE

F. R. WHATMOUGH

The Canadian provincial governments have concerned themselves with the safe operation of domestic and industrial electric equipment by the public. The origin, purpose, scope, and operations of the Approvals Laboratories, which undertake the examination of prototypes of electric apparatus, are briefly described.

IN 1915 The Hydro-Electric Power Commission was authorized by the Province of Ontario to form an electrical inspection department governing the installation of electric equipment. In 1918 the Commission started a laboratory in its research division to supplement field inspection, patterned after the electrical division of Underwriters' Laboratories. It was known as the Approvals Division.

As the Canadian Electrical Code Part I became accepted by other provinces, the approvals services of the Commission were stipulated b them. Because of this interprovincial acceptance it wa decided that the laboratory should not operate under the name of The Hydro-Electric Power Commission of Ontario. Consequently the laboratory became a division o the Canadian Standards Association (a nonprofit organization with a Dominion charter) in May 1940, operating under an agreement with the Commission. In September 1950, the division became entirely divorced from th Commission.

PURPOSE AND SCOPE

THE PURPOSE OF the laboratories is to reduce to a acceptable degree fire and life hazards incident t

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Essentially full text of a conference paper, "The Operations of the Approvals Labora, tories—A Division of Canadian Standards Association," to be presented at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Recommended by the Committee on Industrial Control.

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e operation of electric equipment installed according to e requirements of the Canadian Electrical Code Part I.

The scope of operations depends on the interpretation of e Canadian Electrical Code Part I. This includes all ectric equipment intended to operate at all potentials in ectric installations for buildings, structures, and premises ith the following exceptions:

1. Installations or equipment used by an electrical or mmunication utility in the exercise of its function as a tility, and located outdoors or in buildings or sections of uildings used for that purpose.
2. Car wiring, car houses, and passenger and freight ations used in the operation of electric railways and pplied with electric current from the railway power rcuit.
3. Aircraft and marine work.

OPERATIONS OF THE LABORATORIES

THE ELECTRICAL codes are the basis of the laboratories' operations. The contents of the Canadian Electrical ode Part I correspond to some extent to those of the ational Electrical Code of the United States. With e valuable assistance of the industry and professional ssociations, the laboratories have compiled various lectrical standards which are known as the specifications f the Canadian Electrical Code Part II. The contents f these standards are similar to those of Underwriters' aboratories of the United States. They deal with the fe construction of electric equipment.

About 75 per cent of the 107 specifications are comleted; the remainder are started and are in varying stages f completion. It is estimated that 200 specifications are eeded to cover the domestic and industrial electric quipment field. Codes exist for the users, hence, constant evision and co-ordination are needed.

Part I of the code is compiled by a Part I Committee. ts membership is from electrical manufacturers, inspectors, re marshals, utilities, insurance interests, and so forth.

Part II of the code is compiled by a second Committee. t consists of equal representation from the manufacturing nd nonmanufacturing groups. The former has six embers from Canadian Electrical Manufacturers Associaon (CEMA) and the latter has an equal number from spection, the laboratories, National Research Council, anadian Electrical Association, and Canadian Underriters' Association. A nonvoting corresponding member obtained from the Codes and Standards Committee of ational Electrical Manufacturers Association (NEMA). he Committee has a chairman from the laboratories' ersonnel.

The members of the Part II Committee act as chairmen f one or more subcommittees which are authorized to ompile specifications. The working subcommittees const of representatives from the laboratories, the electrical dustry, and inspection departments. Specifications are rafted and circulated to industry for comment. A eeting, open to industry, is held. When agreement is eached, a final draft is compiled and considered by the art II Committee together with any minority reports. If the committee passes it, the specification is considered by the Part I Committee and finally by a Main Committee of the association. If the latter passes the specification, it is authorized as a standard. This is considered to be a democratic procedure of compiling and authorizing standards because they receive the majority acceptance of industry, inspection, and allied interests.

Much of the equipment examined and tested by the laboratories is not covered completely by a standard. Consequently the laboratories uses, with discretion, information from various other sources such as NEMA and AIEE. In some cases the laboratories invoke requirements based on experience.

THE APPROVALS LABORATORIES

THE LABORATORIES have a staff of 130 people. The engineering department has over 50 technicians and engineers excluding field inspectors.

The laboratories are set up in three groups: administration, engineering, and inspection. The first looks after finance, records, annual agreements, plant, and so forth; the second, engineering and testing; and the third, field reinspection. Recent acquisition to the engineering group is the testing and examination of oil burners done formerly by the National Research Council. The electrical and mechanical engineers do the actual testing and examination, aided by technicians.

The method of handling prototype testing is as follows:

1. Formal application is made by the submitter.
2. A deposit fee is quoted and representative samples are requested (or arrangements made to visit the manufacturer's plant).
3. A project is assigned to an engineering specialist who examines and tests the equipment, advises the submitter of the alterations, and conducts correspondence and interviews, including examination of improved samples if required. To expedite the sale of equipment the laboratories may grant interim approvals. Finally a report is completed and sent to an Approvals Council whose membership consists of the various chief inspectors in Canada. A favourable ballot constitutes formal approval.
4. An agreement for annual factory reinspection is executed to maintain an approval on a yearly basis.

Since the war an average of 1,700 applications annually have been received.

The listings are set up in a card-filing system reflected in a list of approved devices in book form which at present consists of over 700 pages. The listings are used by inspectors, manufacturers, and purchasing agents. Over 11,000 approval numbers are in use, a few of which cover hundreds of separate submittals over a period exceeding 30 years. There are over 33,000 files on approvals. Over 1,100 separate applications are held by engineers on a daily basis of prospective work. Last year over 4,500 reinspections of listed equipment were made at manufacturers' plants.

A manifest of approval is required in the form of a number, label, or monogram. Last year 15,000,000 labels were issued. Reinspections are made one or more times per annum at the manufacturers' plants in the United States, Canada, Great Britain, and Europe.

With the great variety and complication in some applications a "special" approval is used. This consists of a study of equipment, drawings, and engineering practice, and some tests at the submitter's plant. Examples are the more complicated industrial controls, motors, cranes and hoists, and elevator equipment. The complete line then is listed on a broad basis. In testing and examining for safety the procedure is as follows. The sequence of the tests is laid down in the specifications.

1. The rating is checked and it shall not exceed a permissible plus tolerance. It is obvious that inputs should not exceed their markings. As far as outputs are concerned, they are important depending on the application and Part I Code requirements.

2. The normal operating temperatures of the various components are determined.

3. The abnormal operating temperatures are asce tained. This is usually a fire-hazard test in some form an is peculiar to the laboratories. The reason for this obvious—usually fires are started by abnormal condition

4. Leakage currents are measured in some cases, suc as radio receivers.

5. The insulation resistance and dielectric strength a normal operating temperatures are noted.

6. Miscellaneous tests are made depending on th nature of the appliance.

This article has described briefly the basis and opera tions of the laboratories. The safety of the publ in the use of electric appliances is the mutual problem the manufacturer and inspector, with the laboratori acting as the instrument of the latter. The laboratori are conscious of their function, and in their dealings wit industry have endeavoured always to interpret co requirements fairly and consistently.

Electrical Essay

A 4-Point Network

This essay presents a practical problem which comes up when measurements are taken of a portion of a power system on a network analyzer and it is desired to make an equivalent for that portion of the system.

Figure 1 shows a box containing an unknown network.

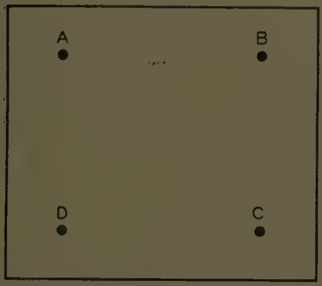

Figure 1

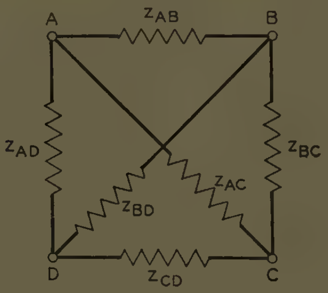

Figure 2

The terminal impedances Z_{AB}, Z_{AC}, Z_{AD}, Z_{BC}, Z_{BD}, and Z_{CD} are measured and known. Determine the impedances of each of the branches Z_{AB}, Z_{AC}, and so forth, in Figure 2 so that the terminal impedances between corresponding terminals will be the same as found in Figure 1.

LYLE A. DUNSTAN (M '47)

(Federal Power Commission, Washington, D. C.)

Answer to Previous Essay

A Distortion Network. The following is the author's answer to his previous essay (*EE, May '51, p 451*).

From the solution of the linear operational equation

$$Z(p)i=e$$

the current taken by the network when the switch is close is determined to be as follows:

$$i=\frac{E}{R}\frac{3\omega p}{p^2+9\omega^2}1=\frac{E}{R}\sin 3\omega t$$

The current in the inductor $8L/3$, the current in th capacitor, and the voltage across the capacitor are expresse by the following equations respectively:

$$i_L=\frac{E}{3R}\frac{\omega p}{p^2+\omega^2}1=\frac{E}{3R}\sin \omega t$$

$$i_C=\frac{8E}{3R}\frac{\omega p^3}{(p^2+\omega^2)(p^2+9\omega^2)}1=\frac{E}{R}\left(\sin 3\omega t-\frac{1}{3}\sin \omega t\right)$$

$$e_C=E\frac{9\omega^2p^2}{(p^2+\omega^2)(p^2+9\omega^2)}1=\frac{9E}{8}(\cos 3\omega t-\cos \omega t)$$

At the instant the switch is opened on the crest of th applied voltage wave, all the above currents and th voltage across the capacitor are equal to zero. There therefore no energy stored in the network, either kinet or potential, and the network will remain de-energize that is, no oscillation will take place after the opening the switch.

The network is named a distortion network since th current drawn by it is of a different frequency than th applied voltage and the apparent power is entirely disto tion power, having no active or reactive components.

A. A. KRONEBERG (F

(Southern California Edison Company, Los Angeles, Cal

NOTE: In the May issue of *Electrical Engineering* the answer to Motionally Induced Electric Fields—Pa VI, page 452, Doctor Slepian said that he would postpo the answer to Question 2 until the June issue. As Doct Slepian is ill, this answer will appear in a later issue.

NSTITUTE ACTIVITIES

Vide Variety of Inspection Trips Planned for Summer General Meeting

Plans for the technical and social program the Summer General Meeting to be held Toronto, Ontario, Canada, June 25–29, e now complete. Headquarters for the eeting is the Royal York Hotel in downwn Toronto, where ample facilities have en reserved for the many technical sessions d for the entertainment and social events hich form such an important part of each mmer Meeting.

Blocks of rooms have been reserved in the adquarters hotel and the King Edward otel, and other accommodations may be tained at the Prince George, Barclay, and alker House Hotels, which are within a e minutes' walk from the Royal York otel.

Toronto is the industrial heart of Southern ntario. It is a city of many cultural stitutions, such as the University of oronto, the Royal Ontario Museum, the oyal Conservatory of Music, the Ontario ollege of Education, and the Art Gallery, d many of its fine churches rank with the st in church architecture on the continent. ere are many recreational parks and aches within its environs.

The technical program covers all phases electrical engineering, with particular nphasis on transmission and distribution. wo of the papers, on Electronic Power onverters and Printed Circuit Techniques, ve been prepared by members of the stitute who reside in the United Kingdom.

At the Annual Meeting to be held at :30 a.m. on Monday, June 25, the mme Medal will be presented to Donald Bohn, Chief Electrical Engineer, Aluminum Company of America, by AIEE President LeClair. (See the story on the Lamme Medal on page 358 of the April issue of *Electrical Engineering*, and the biographical sketch of Mr. Bohn on page 365 of the same issue.)

TECHNICAL PROGRAM

On Monday afternoon following the opening luncheon, the technical program will be initiated with sessions on Distribution, Electronic Power Converters, and Power Generation. At 2:00 p.m. the Vice-Presidents and District Secretaries will hold their annual conference. In the evening the Forum of Technical Committee Chairmen is scheduled for 7:30.

On June 26 technical sessions on Transmission, Hydroelectric Systems, Electronic Instruments, Safety, and Land Transportation will be held. Concurrently, the delegates from each of the Sections will hold their annual conference at 9:30 a.m. In the afternoon there will be technical sessions on Making an Electronics Research Project Successful, Power, Land Transportation, the Petroleum Industry in Canada, Statistical Methods, and Telemetering.

On Wednesday sessions on Insulated Conductors, Carrier Current, Instruments and Basic Measurements, Wire Communications, Electrostatic Processes, Protective Devices, Industrial Power Systems, and a Broad-Band Transcontinental Radio Relay System are scheduled. In addition, the Students who have been awarded the District Branch Paper Prizes in the odd-numbered Districts will present their papers at 9:30 a.m. under the sponsorship of the Members-For-Life Fund.

Technical papers on Switchgear, Transformers, Nucleonics, Mining and Metal Industries, Industrial Control, Management, Feedback Control Systems, and Metallic Rectifiers will be given on June 28.

The technical sessions will be concluded Friday morning with papers on System Engineering, Computing Devices, Basic Sciences, Industrial Control, and a round-table conference session on Temperature Correlation.

ROUND-TABLE CONFERENCE SESSION

A round-table conference session to discuss the problems associated with the connection of insulated wires and cables with their relatively low thermal limits to electric equipment operating at higher temperatures will be the last technical session. This session is under the sponsorship of a project committee appointed by the Institute Standards Committee.

This problem is not a new one but was spotlighted by the objections of the Edison Electric Institute to a proposal by the Institute Switchgear Committee to increase the limiting temperature rise of switchgear assemblies, covered by AIEE Standard *Number 27*, from 30 degrees centigrade to 35 degrees centigrade. As a result, the proposed increase was held up and the Standards Committee appointed a project committee to study the problem and, if possible, to resolve it.

The project committee has prepared a progress report in the form of a guide which will be presented at the round-table conference session and which will serve as the basis of discussion from the floor. The purpose of the discussion is to resolve various temperature standards which have been in

e Sir Adam Beck-Niagara Generating Station Number 1 (left) near Queenston, Canada, was constructed by the Hydro-Electric Power mmission of Ontario, and officially opened on December 28, 1921. The normal operating capacity of the plant is about 525,000 rsepower. Power generating equipment is here seen in various stages of construction in a section of Plant Number 1 (right) of nadian Westinghouse Company, Ltd., at Hamilton, Canada. One of the many interesting inspection trips for members attending the Summer General Meeting in Toronto will be to Canadian Westinghouse

existence on switchgear, industrial control equipment, and other equipment, governing the temperature of outgoing terminals. Several values of temperature rise are specified in the various standards and the important consideration is how to terminate insulated wires and cable on such equipment so that the wires and cable will not overheat.

A group of representatives from the various fields of activity who are competent to discuss the problem will be assembled. The round-table discussion will be strictly informal, no papers are to be presented, and the discussion will not be published.

INSPECTION TRIPS

A wide variety of trips and tours has been arranged during the meeting week. Members making the trips should wear their registration badges for identification purposes and it is not expected at this time that further identification will be necessary for access to the plants to be visited.

A nominal fee will be charged for the transportation for most trips except where a specific fee has been listed with the trip description, in which case the specified fee will be charged to cover transportation and meals where the latter are scheduled.

Canadian-Built Diesel Electric Locomotive (Monday, June 25, 11:00 a.m. to 6:00 p.m.). The Canadian National Railways will have on exhibit in the Union Station yards across the street from the headquarters hotel the first Diesel-electric locomotive manufactured in Canada. Directions will be available at the Trips Desk and guides will be at the exhibit to describe this locomotive.

Hydro-Electric Power Commission of Ontario Laboratories (Monday, June 25, 2:00 p.m.). The Hydro-Electric Power Commission of Ontario, the provincially owned power authority which generates and transmits most of the power developed in Ontario, operates one of the most modern and complete research laboratories in Canada at its Strachan Avenue premises. Many significant electrical developments, including an ultrasonic device for testing large concrete structures, a pulse-type fault locator for high-voltage transmission lines, and a bolometer can be seen at the laboratory. Transportation will be provided by bus.

Future AIEE Meetings

Summer General Meeting
Royal York Hotel, Toronto, Ontario, Canada
June 25–29, 1951
(*Final date for submitting papers—closed*)

Pacific General Meeting (*page 547*)
Multnomah Hotel, Portland, Oreg.
August 20–23, 1951
(*Final date for submitting papers—closed*)

AIEE Conference on Aircraft Equipment
Hollywood Roosevelt Hotel
Los Angeles, Calif.
October 8–10, 1951

AIEE Conference on Fractional Horsepower and Motor Applications to Refrigeration Equipment and Pumps
Dayton, Ohio
October 11–12, 1951

Fall General Meeting
Hotel Cleveland, Cleveland, Ohio
October 22–26, 1951
(*Final date for submitting papers—June 22*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 21–25, 1952
(*Final date for submitting papers—October 23*)

Toronto Rapid Transit System (Tuesday, June 26, 9:00 a.m.). The Toronto Transportation Commission is presently building the first subway for a municipal transportation system in Canada. Much of the excavation of the combined tunnel and open-cut construction has already been completed and sections close to the Royal York Hotel are already poured in concrete. A conducted tour will be made of this project which is being constructed beneath the false decks of Toronto's busiest thoroughfares. The trip will terminate in the Commission's Hillcrest Shops which are among the finest on the continent and are recognized by electrical maintenance engineers for the efficient dispatch with which electrical maintenance and repairs are effected on Toronto's 1,700 transportation units. This tour will start from the Commission's offices, one block from the hotel.

Canadian General Electric Company and Ferranti Electric Limited (Tuesday, June 26, 9:00 a.m.). For those interested in large transformer design, a choice may be made of visiting the transformer plant of the General Electric Company or the Ferranti Electric Limited. In their Davenport works, the General Electric Company manufactures power transformers, distribution transformers, and specialty transformers. A demonstration of artificial lightning by means of a 3,000,000-volt impulse generator will be made. The Canadian branch of Ferranti Limited (England) designs and manufactures transformers, watt-hour meters, and a unique type of voltage regulator in all ratings. X-ray equipment is also manufactured. Members will be conducted to whichever plant they choose by bus.

Canadian Westinghouse Electric Company and Steel Company of Canada (Tuesday, June 26, 1:00 p.m.). These plants are located in Hamilton, one hour's drive from Toronto. Members will have a choice of the plant to be visited, as it will not be possible to cover both plants in the same afternoon. The Westinghouse plant manufactures some of the largest central station equipment in the world, including generators, motors, power transformers, and circuit breakers. This tour also will include the Westinghouse Research and Development Laboratory, which is the largest and most up-to-date industrial laboratory in Canada and has physical, chemical, electrical, and mechanical facilities. The Steel Company of Canada is the largest steel mill in Canada. Visitors will see the huge blast furnaces, coke ovens, open hearth furnaces, blooming and billet mills, bar mills, plate mills, and electrolytic tinning mills, as well as the electric controls and drives for the new 15,000-horsepower cold rolling mill capable of producing 3,000 feet of sheet per minute. Transportation will be by bus and the charge will be $1.50 per person.

New Avro Jet Transport (Tuesday, June 26, 2:00 p.m.). An opportunity will be provided to inspect the first jet-driven passenger transport manufactured on th
continent. This plane, designed by t
A. V. Roe Company, recently has made
number of record-breaking trial flights
the United States and Canada, cutti
airline schedules in half. The trip is cond
tional on this aircraft being in Toronto
this date or some other date during the wee
and members must inquire at the Tri
Desk for the actual date and time. Tra
portation will be by bus.

Bell Telephone Company's Elgin Buildi
(Tuesday, June 26, 2:00 p.m.). Visit
will see the largest long-distance swit
board installation in Canada. Inwa
outward, and tandem switchboards totalli
479 positions provide the long-distan
service for Toronto's 425,000 telepho
stations. Terminating equipment in t
toll terminal room provides for 2,300 t
circuits, including 600 *K* carrier telepho
circuits operating through a vast netwo
of cables linking the major telephone cent
in Canada and the United States. T
building also contains five units of step-b
step dial equipment. Guides will esc
members from the headquarters hotel to t
telephone center close by.

Niagara Falls and the Welland Canal—A
Day Trip (Wednesday, June 27, 9:00 a.m
Niagara Falls will be visited in the mornin
Luncheon will be taken at Queenst
Heights, a historic park of national interest
both Canadians and Americans. The
turn trip will be by way of the Wella
Canal where the largest twin flight locks
the world will be inspected at Thoro
These are a duplication, side by side, of th
successive gigantic locks so constructed as
permit up-bound and down-bound la
and ocean-going vessels to pass without del
The trip will be made by bus and the cha
will be $4.50 per person, including lunche

Dunlap Observatory (Wednesday, June
8:30 p.m.). Canada's largest observato
associated with the University of Toron
is located 15 miles north of Toronto. T
trip should appeal to both members and th
ladies. The Observatory Staff has arrang
a conducted tour, and, weather permitti
the visitors will be able to examine
heavens through the observatory's 74-in
reflecting telescope. It is expected t
Dr. Helen Hogg, one of the foremost wom
astronomers in the world, will be in
tendance to welcome the ladies in the par
Transportation will be by bus from the ho
and the charge will be $1.00 per person.

Canadian General Electric Company, Pet
borough—All-Day Trip (Thursday, J
28, 8:30 a.m.). Located 90 miles northe
of Toronto, this mammoth Canadian affili
of the General Electric Company ma
factures water-wheel generators larger th
100,000 kva, and units for many of
major power developments currently
progress in Canada are being assemb
here. This trip will include a view of
highest marine lift lock in the world. Lu
will be provided through the courtesy of
Canadian General Electric Compa
Transportation will be by car and the cha
will be $1.50 per person.

Leaside Industrial Plants (Thursday, J
28, 2:00 p.m.). Leaside, in the east en

(*Continued on page 545*)

Tentative Technical Program

Summer General Meeting, Toronto, Canada, June 25–29

onday, June 25

:00 a.m. Opening Ceremony

:30 a.m. Annual Meeting

Report of Board of Directors. H. H. Henline, retary.

Report of Treasurer. W. I. Slichter.

Report of Committee of Tellers on:

Votes for nominees for AIEE offices.

Proposed Constitutional amendments.

(*a*) Introduction of, and presentation of President's dge to, F. O. McMillan.

Response by Professor McMillan.

Presentation of Lamme Medal to Donald I. Bohn, ief Electrical Engineer, Aluminum Company of erica.

The Establishment of the Medal. A. H. Kehoe, airman, Lamme Medal Committee.

The Career of the Medalist. Thomas D. Jolly, ce-President and Chief Engineer, Aluminum Company America.

Presentation of Medal and Certificate by President Clair.

Response by Mr. Bohn.

Any other business that may be presented.

The Power to Progress, President T. G. LeClair.

00 p.m. Distribution

-193. Economic Primary Circuit Design Beneficially adied by Unit System. *D. K. Blake*, General Electric mpany

-194. The Linascope Transmission Line Fault cator. *K. H. Kidd*, The Hydro-Electric Power Comssion of Ontario

-195. Current Carrying Capacity of ACSR Conctors. *J. H. Waghorne*, *V. E. Ogorodnikov*, The Hydroectric Power Commission of Ontario

. Design Features of Rural Electrification in tario.** *R. E. Jones*, The Hydro-Electric Power Comssion of Ontario

:00 p.m. Electronic Power Converters

-206. Inductive Co-ordination Aspects of D-C stems Supplied by Rectifiers. *Working Group on port of Inductive Co-ordination Aspects of D-C Systems pplied by Rectifiers*

-207—ACO.* Equivalent Machine Constants for ectifiers. *I. K. Dortort*, I-T-E Circuit Breaker Comny

-209—ACO.* Some British Electronic Power Conrters. *J. E. Boul*, English Electric Company, Ltd.

-210. Analysis of the Three-Phase Inverter with sistive Load. *R. E. Turkington*, Massachusetts Intute of Technology

-211. Commutating Reactor Control for Mechani Rectifiers. *E. J. Diebold*, I-T-E Circuit Breaker mpany. Presentation by title only for discussion

-212. Development of a Pumpless Ignitron. *C. C. rskind*, *E. J. Remscheid*, General Electric Company. esentation by title only for discussion

-227. Basic Heat-Transfer Data in Electron Tube peration. *Mrs. F. F. Buckland*, General Electric mpany

:00 p.m. Power Generation

. Simplified Measurement of Subtransient and gative Sequence Reactances in Salient Pole Synronous Machines.** *F. K. Dalton*, *A. W. W. Cameron*, e Hydro-Electric Power Commission of Ontario

CP. Differential Movement of Stator Coils and Iron in Turbine Generators.** *M. D. Ross*, *E. I. King*, *M. M. Matthews*, Westinghouse Electric Corporation

51-196. Static Magnetic Exciter for Synchronous Alternators. *H. F. Storm*, General Electric Company

51-197. Elements of System Capacity Requirements. *C. W. Watchorn*, Pennsylvania Water and Power Company

51-198. Determination of Reserve Capacity by the Probability Method—Effect of Interconnections. *G. Calabrese*, New York University. Presentation by title only for discussion

Tuesday, June 26

9:30 a.m. Transmission

51-203. Transmission Systems of the Hydro-Electric Power Commission of Ontario. *J. E. Sproule*, *F. L. Code*, The Hydro-Electric Power Commission of Ontario

51-204. Analysis of Total and Incremental Losses in Transmission Systems. *L. K. Kirchmayer*, General Electric Company; *G. W. Stagg*, American Gas and Electric Service Corporation

51-205. The Torsional Damper for Conductors—Service Experience and Further Experimental Work. *T. J. Burgess*, *A. D. Hogg*, The Hydro-Electric Power Commission of Ontario

CP. Line Outages on Transmission Lines of 100 Kv and Above.** *Joint AIEE-Edison Electric Institute Subcommittee*

9:30 a.m. Hydroelectric Systems

51-213—ACO.* The Progressive Development of Hydro-Electric Stations on the Upper St. Maurice River. *E. V. Leipoldt*, The Shawinigan Engineering Company, Ltd.

51-214—ACO.* Prime Mover Equipment in New Ottawa River Developments at Des Joachims, Chenaux, and La Cave for the Hydro-Electric Power Commission of Ontario. *A. E. Aeberli*, *G. F. Simson*, The Hydro-Electric Power Commission of Ontario

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES for papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

CP. Planning and Design of Beauharnois Powerhouse Number 2.** *H. F. Abbott*, Beauharnois Light, Heat and Power Company

51-216—ACO.* Modern Trends in the Design of Vertical Waterwheel Generators. *C. M. Laffoon*, *E. C. Whitney*, *R. A. Baudry*, Westinghouse Electric Corporation

9:30 a.m. Joint Subcommittee on Electronic Instruments

51-217. On the Mechanics of Magnetic Amplifier Operation. *R. A. Ramey*, Naval Research Laboratory

CP. Anodige, an Electrical Analogue-to-Digital Converter.** *M. L. Kuder*, National Bureau of Standards

CP. A Sweep Frequency Generator for the UHF Television Band.** *John Cornell*, Radio Corporation of America, Victor Division

51-218. A Servo System for Heterodyne Oscillators. *T. Slonczewski*, Bell Telephone Laboratories, Inc.

9:30 a.m. Safety

51-281. Electric Shock. *Wills Maclachlan*, Maple, Ontario, Canada

51-282. Electric Insect Traps. *C. F. Dalziel*, University of California

9:30 a.m. Land Transportation

51-220. Economic Factors Which Influence Dieselization and Electrification. *Charles Kerr, Jr.*, Westinghouse Electric Corporation

CP. Railway Electrification, Diesel-Electric Locomotives and Some Future Aspects of Electric Traction.** *G. Huldschiner*, College of the City of New York

51-221. Economic Evaluation of Fuel and Energy, Sources for Railway Motive Power. *T. M. C. Martin*, Bonneville Power Administration

51-222—ACO.* Railway Electrification—A Prospective Consumer of Central Station Power. *Llewellyn Evans*, Tennessee Valley Authority

2:00 p.m. Power

51-223. Brief Description on Static Power Condensers for High Voltage Use in Japan. *K. Kitagawa*, Sumitomo Electric Industries, Ltd.; *T. Omori*, Nissin Electric Company, Ltd.

51-224. Line Insulator Loss Under Normal Conditions—500-Kv Test Project of the American Gas and Electric Company. *O. Naef*, American Gas and Electric Service Corporation; *R. L. Tremaine*, *A. R. Jones*, Westinghouse Electric Corporation

51-225. Tensorial Analysis of Integrated Transmission Systems—I—The Six Basic Reference Frames. *Gabriel Kron*, General Electric Company

51-226. Determination of Instantaneous Currents and Voltages by Means of Alpha, Beta, and Zero Components. *W. C. Duesterhoeft*, *Edith Clarke*, University of Texas; *M. W. Schulz, Jr.*, General Electric Company

2:00 p.m. Making an Electronics Research Project Successful

CP. Teamwork in Research Produces the Fluoricon.** *J. W. Coltman*, Westinghouse Electric Corporation

CP. Getting Results from Research in Electronics.** *E. H. Schulz*, Armour Research Foundation

CP. Some Case Histories of Electronic Research.** *R. M. Bowie*, Sylvania Electric Products, Inc.

CP. The Transistor—A Case History in Research and Development.** *J. B. Fisk*, Bell Telephone Laboratories, Inc.

2:00 p.m. The Petroleum Industry in Canada

CP. The Development of the Petroleum Industry**

ACO: Advance copies only available; not intended publication in *Transactions*.

CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

in Canada. *J. F. Fairlie*, Imperial Oil Limited

CP. Features of a Gas Turbine Centrifugal Compressor Station for Gas Line Pumping.** *J. S. Quill*, General Electric Company

CP. Electric Installations in a Refinery.** *A. K. Meen*, British American Oil Company

CP. Submergible Pumps for the Petroleum Industry.** *Joe Carle*, Reda Pump Company

2:00 p.m. Telemetering

51-228. A High Speed Telemetering System with Automatic Calibration. *W. E. Phillips*, Leeds and Northrup Company

51-229. Choice of Telemetering Systems and Channels for a Power System. *C. K. Duff*, The Hydro-Electric Power Commission of Ontario

CP. FM/FM Telemetering.** *Leroy Walters*, The Johns Hopkins University

CP. Recent Developments in Miniaturized PDM/FM Telemetering.** *A. N. Hill, Jr.*, ASCOP

CP. A Historical Review of Telemetering.** *P. A. Borden*, The Bristol Company; *W. J. Mayo-Wells*, The Johns Hopkins University

2:00 p.m. Land Transportation

51-230. Rapid Transit Developments in Toronto. *J. G. Inglis*, Toronto Transportation Commission

51-231—ACO.* Conversion of 3,000-Volt D-C Locomotive for Operation on 600 Volts. *F. D. Gowans*, General Electric Company

51-232. Regeneration with a Mercury Arc Rectifier on the Central Railway of Brazil. *A. Schmidt, Jr.*, General Electric Company

51-185. Power Supply Study and New Rectifier Installation for the United Electric Railways of Providence. *W. C. Whitman, F. F. Schaller*, New England Power Service Company. Presentation by title only for discussion

2:00 p.m. Conference on Statistical Methods

51-283—ACO.* The Quality Control Indicator. *C. J. Falk*, General Electric Company

CP. Applications of Statistical Methods and Specifications and Tests of Electronic Equipment.** *Leon Bass*, General Electric Company

CP. Applications of Statistical Methods in the Hydro-Electric Power Commission of Ontario.** *E. L. Hartman*, The Hydro-Electric Power Commission of Ontario

Wednesday, June 27

9:30 a.m. Insulated Conductors

CP. Underground Domestic Distribution—Status in Canada.** *P. J. Croft*, Canada Wire and Cable Company, Inc.

51-233. Electrical Characteristics of a Three-Phase Delta Submarine Power Cable Circuit Using Earth as One Conductor. *F. O. Wollaston*, British Columbia Electric Railway Company, Ltd.

51-234. F-3 Lead Alloy Cable Sheath—Effect of Bending and Creep on Life. *L. F. Hickernell, A. A. Jones, C. J. Snyder*, Anaconda Wire and Cable Company

51-235. Cables for Vertical Risers. *W. T. Peirce*, American Steel and Wire Company

9:30 a.m. Carrier Current

51-236. Carrier Current Supervisory System for Distribution Circuits. *L. Podolsky, S. Lubin*, Sprague Electric Company

51-237. Application of Power Line Outage Monitor. *J. F. Atkinson*, Rural Electrification Administration; *J. D. Cooke*, Central Virginia Electric Co-operative

51-188. Signal and Supervision Systems Used on Carrier Current Communications Circuits. *R. L. Mayer*, Pacific Gas and Electric Company

CP. Microwave Communication Systems.** *F. M. Rives*, General Electric Company

9:30 a.m. Basic Instruments

51-238. A Tachometer for Measurement of Instantaneous Variations in Angular Velocity. *S. P. Bartles*, Eastman Kodak Company

51-239. A Magnetic Tape Oscillograph for Power System Analysis. *E. C. Schurch, F. R. Schleif*, Bureau of Reclamation

51-240. Some Engineering Applications of the Electrolytic Field Analyzer. *H. K. Farr, W. R. Wilson*, General Electric Company

51-219. A Multi-Purpose Bridge-Type Phasemeter. *G. A. Armstrong*, Vancouver, British Columbia

9:30 a.m. Wire Communications

51-241—ACO.* Preservative Treatment of Poles. *H. F. Bush, A. R. Colman*, The Bell Telephone Company of Canada

51-242. A Practical Application of Low Frequency Magnetic Induction Theory. *R. N. E. Haughton*, The Bell Telephone Company of Canada

CP. Canadian National Telegraph's Communication System.** *R. B. Steele*, Canadian National Telegraphs

9:30 a.m. Electrostatic Processes

51-199. Electrostatic Sources of Ionizing Energy. *J. G. Trump*, Massachusetts Institute of Technology

51-200. Particle Charging in Electrostatic Precipitation. *H. J. White*, Research Corporation

51-201. Electrostatic Precipitation of High-Resistivity Dust. *G. W. Penney*, Carnegie Institute of Technology

51-202. Distribution of Charge in Electrostatic Separation. *Foster Fraas, O. C. Ralston*, Bureau of Mines

2:00 p.m. Protective Devices

51-190. The Duty on Lightning Arresters for A-C Systems. *Edward Beck*, Westinghouse Electric Corporation

51-278. Long-Duration Surge Testing of Lightning Arresters. *S. B. Howard, T. J. Carpenter, H. Schwartz*, General Electric Company

51-189. Spiral Arc Chokes Power Flow in New Arresters. *Otto Ackermann, E. J. DeVal*, Westinghouse Electric Corporation

51-285—ACO.* Lightning Arrester Application Guide—Preliminary Working Group Report. *Project Committee on Application Guide of Methods for Lightning Protection of Substations*

51-279. Transmission and Distribution Grounding in the Hydro-Electric Power Commission of Ontario. *W. W. Loucks, W. A. R. Lemire*, The Hydro-Electric Power Commission of Ontario

51-280. Standardization of Ratings of Neutral Grounding Reactors. *J. L. Thomason*, General Electric Company. Presentation by title only for discussion

2:00 p.m. Carrier Current

51-187. A Study of Carrier-Frequency Noise on Power Lines—Part I. Theoretical Considerations and Measuring Techniques. *R. C. Cheek, J. D. Moynihan*, Westinghouse Electric Corporation

51-245. A Study of Carrier-Frequency Noise on Power Lines—Part II. Results of Field Measurements. *R. C. Cheek, J. D. Moynihan*, Westinghouse Electric Corporation

51-246. Transmission Considerations in the Co-ordination of a Power Line Carrier Network. *G. E. Burridge, A. S. G. Jong*, The Hydro-Electric Power Commission of Ontario

51-244. British Developments and Applications of Carrier Current Principles for Operating Requirements of Power Utilities. *W. D. Goodman*, General Electric Company, Ltd.

51-192. Measurements and Tests on a Power Line Carrier Relaying System. *R. H. Miller, A. R. Worthington*, Pacific Gas and Electric Company. Presentation by title only for discussion

2:00 p.m. Basic Instruments

51-182. Improvements in Transformer-Loss Compensators for Watt-Hour and Var-Hour Meters. *G. B. Schleicher*, Philadelphia Electric Company

51-183. The Induction Galvanometer, A Sensitive Instrument Converter. *R. W. Gilbert*, Weston Ele trical Instrument Corporation

51-184—ACO.* Unbalance Measurements of Fou Branch Networks. *B. M. Wojciechowski*, Western Ele tric Company

51-186. Results of a Questionnaire Covering Current Practices in Electrical Tests on Dielectrics in th Field. *Subcommittee on Electrical Tests on Dielectrics i the Field.* Presentation by title only for discussion

51-247. The Hot Spot Rise Simulator. *C. F. Boo V. V. Mason*, The Hydro-Electric Power Commission Ontario

2:00 p.m. Instruments and Measurements and Transformers

51-247. The Hot Spot Rise Simulator. *C. F. Boo V. V. Mason*, The Hydro-Electric Power Commission Ontario

2:00 p.m. Industrial Power Systems

51-248. Protective Relaying on Industrial Powe Systems. *C. M. Lathrop, C. E. Schleckser*, Standard O Development Company

51-249—ACO.* An Industrial Power Distributio System. *H. W. deSalis*, Canadian Westinghouse Company, Ltd.; *J. D. Abell*, International Harvester Company of Canada, Ltd.

CP. A Design of a Canadian Petroleum Refiner Power System.** *James Guthrie*, Imperial Oil Limite *H. C. Mayo*, Kellogg Company

51-250. Industry Plant Power Sources. *R. Woodruff*, Aluminum Ore Company. Presentation b title only for discussion

CP. A Down-to-Earth Discussion of Industri System Neutral Grounding as Influenced by Ove voltages.** *R. H. Kaufmann*, General Electric Compa

51-251. Problems Confronting the Designer i Starting Large Motors. *C. M. Lathrop, C. E. Schleckse* Standard Oil Development Company

51-252. High Voltage Motor Controllers Co-ord nated with Distribution Switchgear. *T. B. Mo gomery, T. H. Bloodworth*, Allis-Chalmers Manufacturi Company. Presentation by title only for discussion

2:00 p.m. A Broad-Band Transcontinental Radio Relay System

CP. Transcontinental Radio Relay System.** *T. Grieser, A. C. Peterson*, Bell Telephone Laboratories, Inc.

CP. Unattended Radio Relay Repeater.** *R. Friis, K. D. Smith*, Bell Telephone Laboratories, Inc.

CP. FM Broad-Band Radio Relay Terminal.** *G. Chaffee, J. B. Maggio*, Bell Telephone Laboratori Inc.

2:00 p.m. Insulated Conductors

51-253. The Determination of Temperature Tran ients on Cable Systems by Means of an Anal Computer. *J. H. Neher*, Philadelphia Electric Company

CP. Rapid Measurement of the Thermal R sistivity of Soil.** *V. V. Mason, M. Kurtz*, The Hydr Electric Power Commission of Ontario

51-254. Voids, Ionization and Wax in Solid Hig Voltage Cables. *F. J. Pohnan* (Deceased). Presen tion by A. L. Brownlee, Commonwealth Edison Company

CP. Surface Discharges from Cable Sheaths a Their Relation to Electric Shock.** *E. W. Greenfie* Anaconda Wire and Cable Company

Thursday, June 28

9:30 a.m. Switchgear

51-255—ACO.* Field Tests on Single Tank 138- 2,500-Mva Oil Circuit Breaker. *G. W. N. Fitzger* The Hydro-Electric Power Commission of Ontar *D. F. Rankine*, Canadian General Electric Company, L

51-256. Field Tests at Grand Coulee Dam on 10,00 Mva 230-Kv Low Oil Content Impulse Circ Breaker. *A. F. Darland, C. L. Killgore*, Bureau of Rec mation; *C. J. Balentine, E. B. Rietz*, General Elec Company

51-257. Interrupting Capacity Verification 10,000,000-Kva 230-Kv Oil Circuit Breakers

and Coulee Power Plant. *A. F. Darland, W. H.* *gett*, Bureau of Reclamation; *W. M. Leeds*, Westing- use Electric Corporation

-258. **Operation of Bushings in Carbonized Oil.** . *R. Wilson, L. Wetherill*, General Electric Company. esentation by title only for discussion

30 a.m. Transformers

-259. **Operating Problems of Forced Oil Forced r Cooled Transformers.** *A. L. Hough*, The Shawini- n Water and Power Company

-208. **Inhibited Oils for Transformers.** *Herman lperin, H. A. Adler*, Commonwealth Edison Company

-260. **Relative Performance of Normal Oils with d without DBPC Inhibitor in Semisealed Trans- rmers.** *E. D. Treanor, E. L. Raab*, General Electric ompany

-261—ACO.* **Field Screening Test for Judging e Condition of Used Insulating Oils.** *R. G. Call*, . *L. Webb*, American Gas and Electric Service Cor- ration

:30 a.m. Nucleonics

.-262. **A Portable Electronic Pile Kinetic Simu- tor.** *Walter Pagels*, Westinghouse Electric Corporation

P.** **The Chalk River N.R.X. Nuclear Reactor in peration.** *D. G. Hurst*, National Research Council

P.** **The 70-Mev Synchrotron at Queens Uni- ersity.** *J. A. Gray*, Queens University; *R. N. Edwards*, eneral Electric Company

:30 a.m. Metal Industry

P.** **The Co-ordination of Control and Drive quipment on Electric Travelling Crane Bridges.** . *C. McCrady*, Steel Company of Canada

1-263. **A Heavy Duty Slip Regulator for Steel Mill ervice.** *W. Schaelchlin, G. E. Mathias*, Westinghouse ectric Corporation

P.** **Rotating Regulator Applications in the Steel d Allied Metal Working Industry.** *W. R. Harris*, estinghouse Electric Corporation

P.** **Types of Fault Indicating Control Used with o-ordinated Electric Drives for Steel Mills.** *R. L. oulton*, General Electric Company

:30 a.m. Management

P.** **Human Relations—Challenge to Manage- ent and to the Social Sciences.** *V. W. Balden*, The niversity of Toronto

P.** **Measurement and Management.** *R. Pres- ave*, York Knitting Mills Limited

: 00 p.m. Relays and Transformers

1-264. **The Application of Class-H Insulation to ransformers.** *M. L. Manning*, Pennsylvania Trans- rmer Company

P.** **Design Requirements for Large H.V. Power ransformers.** *W. G. James*, Westinghouse Electric orporation

P.** **Calculation of Overvoltages in Series Satu- able Circuits.** *A. Boyajian, G. Camilli*, General Electric ompany

P.** **Transient Characteristics of Capacitance otential Devices.** *Subcommittee on Instrument Trans-*

1-284. **Operating Experience with Ground Dis- nce Relays.** *M. P. Osburn, P. L. Dandeno*, The ydro-Electric Power Commission of Ontario

1-265—ACO.* **Temperature Testing of Trans- rmers by Load Back Methods.** *M. C. Hughes*, Agricultural and Mechanical College of Texas

51-266. **The Inrush of Magnetizing Current in Single-Phase Transformers.** *L. A. Finzi*, Carnegie Institute of Technology; *W. H. Mutschler, Jr.*, Allis-Chalmers Manufacturing Company. Presentation by title only for discussion

2:00 p.m. Feedback Control Systems

CP.** **The Use of Feedback Systems for the Control of Anesthesia.** *R. G. Bickford*

CP.** **An Electronic Apparatus for the Study of the Human Operator in a One-Dimensional Closed-Loop, Continuous Pursuit Task.** *C. E. Warren, P. M. Fitts, J. R. Clark*

51-267. **Synthesis of Feedback Control Systems by Means of Pole and Zero Location of the Closed Loop Function.** *M. R. Aaron*, Philadelphia, Pa.

51-268. **Stability of Varying-Element Servomechanisms with Polynomial Coefficients.** *M. J. Kirby, R. M. Giulianelli*, Sperry Gryoscope Company

51-269. **Servomechanism Transient Performance from Decibel-Log Frequency Plots.** *H. Harris, Jr., M. J. Kirby, E. F. von Arx*, Sperry Gyroscope Company. Presentation by title only for discussion

51-270—ACO.* **A Direct Reading Phasemeter for Use in Sinusoidal Measurements on Carrier-Type Servomechanisms.** *R. J. Amorosi*, Sperry Gyroscope Company; *W. E. Meserve*, Cornell University

51-271—ACO.* **An Electro-Mechanical A-C Line Voltage Stabilizer.** *D. M. Murray, N. L. Kusters*, National Research Council

2:00 p.m. Mining and Metal Industry—Industrial Control

CP.** **The Part That A Program of Continued Education Can Play in the Mining Industry.** *G. T. Harley*, International Minerals and Chemical Corporation

CP.** **Amplidyne Mine Hoist Control.** *W. T. Fanjoy*, General Electric Company

51-272. **Analysis of Power Costs of Bituminous Coal Mines.** *H. P. Musser*, West Virginia Engineering Company. Presentation by title only for discussion

CP.** **Electrical Phase of Copper Mining at Noranda.** *C. W. Justice, B. C. Rochester*, Noranda Mines, Ltd.

CP.** **Electrical Applications in the Mining Operations of International Nickel Company.** *I. J. Simcox*, International Nickel Company

2:00 p.m. Metallic Rectifiers

51-273. **Metallic Rectifiers in Telephone Power Plants.** *D. E. Trucksess*, Bell Telephone Laboratories, Inc.

CP.** **Selenium Rectifiers for Self-Saturating Amplifiers.** *J. R. Conrath*, Vickers, Inc.

CP.** **Selenium Rectifiers as Power Supply and Selective Circuits in Business Machines.** *J. L. Wagner*, International Business Machines Corporation

CP.** **Selenium Rectifier Production.** *G. Ramsey*, Fansteel Corporation

CP.** **Magnesium Copper Sulphide Rectifiers in Resistance Welding Machines.** *M. F. Gamble*, P. R. Mallory Company

51-274. **Transient Conditions in a Transformer Supplying Energy to a Half-Wave Rectifier Circuit.** *P. N. Martin*, Union Switch and Signal Company

Friday, June 29

9:30 a.m. System Engineering

Colfax Stability Tests. (Motion Picture). *A. P. Hayward*, Duquesne Light Company

CP.** **Voltage Control on an A-C Power System.** *H. B. Smith*, Niagara Mohawk Power Corporation

51-275—ACO.* **Savings from Generator Bus Voltage Regulation in Conjunction with Automatically Controlled Capacity.** *D. R. Pattison, F. M. Reed*, Pennsylvania Electric Company

CP.** **Operations of A-C Networks, Kansas City Power and Light Company.** *D. H. Cameron, H. W. Phillips*, Kansas City Power and Light Company

CP.** **Control of Voltage on a Hydro-Electric Power System.** *J. M. Crawford, J. A. Smith*, Shawinigan Water and Power Company

CP.** **Control of Voltage Levels and Megavar Flow on 230- and 115-Kv Systems of the Hydro-Electric Power Commission of Ontario.** *P. L. Dandeno, H. W. Nablo*, The Hydro-Electric Power Commission of Ontario

9:30 a.m. Computing Devices

CP.** **The University of Toronto Model Digital Computer.** *J. Kates*, University of Toronto

CP.** **Notes on the Design of Eccles-Jordan Flip-Flops.** *M. Rubinoff*, University of Pennsylvania

CP.** **A Graphical Method of Flip-Flop Design.** *R. F. Johnston, A. G. Ratz*, University of Toronto

CP.** **Some Applications of the Additron.** *T. K. Cranston, G. C. Helwig*, Ferranti Electric Ltd.

51-276. **The Scotch Plaid Raster.** *J. Kates, V. G. Smith*, University of Toronto

CP.** **A Multiplying Counter.** *E. J. Miller*, Royal Canadian Navy

9:30 a.m. Basic Sciences

51-277. **Method for the Determination of Hysteresis Loop Area.** *W. B. Conover*, General Electric Company

CP.** **Analogous Structural-Electrical Energy Relationships.** *F. L. Ryder*, Perkin-Elmer Corporation

51-191. **A New Method for Treating Electron Tubes When Used as Oscillators in the Free as Well as in the Synchronised States.** *A. El-Samie Mostafa*, Farouk I University; *M. El-Shishini Bey*, Member of Egyptian Senate

9:30 a.m. Industrial Control

CP.** **The Influence of Application Requirements on Control Design.** *K. A. Rapsey*, Square D Company of Canada, Ltd.

CP.** **Rheostatic Control of Shunt Fields.** *C. A. MacPherson*, Canadian Controllers Ltd.

CP.** **The Application and Standardization of High Rupturing Capacity Current Limiting Fuses.** *J. W. Gibson*, General Electric Company, Ltd.

CP.** **The Operation of the Approvals Laboratories, Division of Canadian Standards Association.** *G. Moes, F. R. Whatmough*, Canadian Standards Association

9:30 a.m. Round-Table Conference Session on Temperature Correlation in the Connection of Insulated Wires and Cables to Electric Equipment

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(Continued from page 542)

oronto, has a number of electrical manu- cturing plants which produce a wide ariety of electric equipment and appliances. Members may select two of the following lants to visit: Sangamo Company Limited, incoln Electric Company of Canada imited, Minneapolis-Honeywell Regulator ompany Limited, and the Canadian Radio Manufacturing Corporation Limited, where motors, meters, electric welding equipment, regulating and control equipment, and radio and television products are manufactured. Transportation will be by bus.

Bell Telephone Company's Carrier Systems (Thursday, June 28, 1:30 p.m.). This trip will include an inspection of three units which are typical of broad-band carrier telephone systems. The first point to be visited will be an unattended *K* carrier repeater station at Rosebank, 17 miles east of Toronto. The next place on the tour is the Oshawa office, 17 miles east of Rosebank. This office contains a variety of carrier equipment including terminals of the type *C*, *H*, and *K* systems, repeaters for the type *K* systems, and group conversion equipment for joining together type *J* and type *K* systems. The Cannington *J* repeater station, 35 miles north of Oshawa, will be inspected. This is the first repeater station on the *J* carrier route which extends from Oshawa over 1,200 miles to Winnipeg. The tour will be made by bus and the charge will be $2.00 per person.

Miscellaneous Plants. Many electrical manufacturers in the Toronto area have extended an invitation to the members to visit their plants on an informal basis during the meeting week. Members wishing to visit plants of particular interest should inquire at the Trips Desk for the list of manufacturers extending this invitation.

SOCIAL PROGRAM

Highlights of the social program include the President's reception, social evening and dancing at Hart House, University of Toronto, and a formal dinner and dance. Afternoon tea will be served at the Royal York Hotel on Sunday, June 24, between 3:30 and 5:30 p.m. to welcome members and their wives who arrive in advance of the first meeting day. There will be no charge for this tea.

The luncheon on Monday, June 25, will serve to officially open the meeting and welcome the members as guests of the Toronto Section. On Monday evening a buffet dinner will be served at 7:00 p.m., followed by the President's reception and a dance commencing at 8:30 p.m. Tickets for dinner and dance are $5.00 per person.

An outstanding social event will take place at Hart House, University of Toronto, on Tuesday evening at 8:45 p.m. Following a carillon welcome, there will be a theater play, variety entertainment, and square and round dancing. The charge for the full evening's event will be $3.50 per person.

The Toronto Camera Club will present a choice collection of colored stills, followed by a delightful and interesting movie depicting Indian folklore, on Wednesday evening, June 27, at the Royal York Hotel. There will be no charge.

Thursday evening, June 28, the formal dinner and dance will wind up the social part of the meeting. Dinner will commence at 7:00 p.m. and dancing at 9:00 p.m. The Leslie Bell Singers, an all-girl choir, will entertain following dinner. Both events will take place in the Royal York Hotel and dinner will be $4.00 per person and the dance $2.00 per person.

LADIES' ENTERTAINMENT

A special program of trips and events has been prepared for the women guests. The Sunday afternoon tea on June 24 launches the ladies' program, followed on Monday, June 25, with a sight-seeing tour commencing at the hotel at 1:30 p.m. After touring Casa Loma, Toronto's castle of Gothic architecture, the party will proceed to Queens Park where they will be received by the Lieutenant-Governor, the Honourable Ray Lawson, at tea at 4:00 p.m. Tuesday, June 26, at 1:30 p.m., another sight-seeing tour through the residential area of the city will culminate in a tea at the T. Eaton Company's College Street store. On Wednesday evening the ladies will have the choice of accompanying the men on the trip to the Dunlap Observatory or enjoying the movies and still pictures at the hotel. Thursday there will be a tour of the city beginning at 2:00 p.m., including Toronto's lakefront and exhibition grounds and the James flower gardens, with tea at the Old Mill.

A charge of $1.00 per person will be made to cover transportation for each of the tours. Coffee will be served without charge each morning between 10:00 and 11:00 a.m. in Parlour "C" at the Royal York Hotel.

SPORTS

Golf and tennis have been arranged for the male members and their guests. The annual golf tournament for the Mershon Golf Trophy will be held at the Elms Golf and Country Club on Tuesday, June 26. Entries should be registered at the Sports Information Desk. Green fees will be $3.00 per player and transportation will be provided by the Sports Committee to start play between 8:30 and 10:30 a.m. Locker space, rental clubs, caddie carts, and refreshments are available at the club. The Sports Committee will do everything within its power to insure that the handicaps are equitable, and reserves the right to alter any handicaps which, upon investigation, are found to be inequitable. Each contestant's handicap will be based on the average of the five best scores made in 1950 at his regular course. This average and the Club's par must be turned in at the time of registration and the handicap will be computed in accordance with the "National Handicap Table." This handicap will be used in "medal" or "score" play. The Mershon Golf Trophy will be presented to the winner of 18 holes medal play and, in addition to the trophy, the winner will also receive a "Special Prize." There will be other prizes awarded for players with low gross and low net scores. Arrangements may be made for noncompetitive play on several other courses in the city.

The annual competition for the Mershon Tennis Trophy for men will be played at the Toronto Cricket Club on Tuesday, June 26, between 10:00 a.m. and 5:00 p.m. Entries should be registered at the Sports Information Desk. Fees will be $2.00 per player and transportation and tennis balls will be provided by the Sports Committee. Locker space will be provided and refreshments will be available. The Mershon Tennis Trophy will be engraved with the winner's name, and the winner will be presented with a suitable memento of the event. The runner-up will also receive a prize.

REGISTRATION

The mailed advance registration card should be filled in and returned promptly. Members are asked particularly to check off the trips and events which they plan to attend. The registration fee will be $3.00 for members and $5.00 for nonmembers. No fees will be required from students or families of members. Remittance should not be enclosed; fees will be collected when registering. For information on accommodations at the Royal York and King Edward Hotels see page 456 of the May issue of *Electrical Engineering*.

TRANSPORTATION

Toronto is accessible by highway, railway, and airline from all major cities in the United States. For those motoring to the meeting, it is suggested that, if possible, they plan their itinerary to enter Ontario at Niagara Falls and drive from there Toronto over the magnificent Queen Eliz beth Highway. Other points of entry Ontario offering interesting scenic driv from the border to Toronto are the Ivy L bridge near Alexandria Bay, the Pea bridge at Buffalo, the Ambassador brid at Detroit, and the Blue Water bridge Port Huron.

Canadian railroads connect with all lin in the United States and through sleepe are available from all major terminals Toronto. Two major airlines serve Toron from the larger cities in Canada and th United States. Trans Canada Airlin have direct flights from Boston, Clevelan Detroit-Windsor, New York, Sault Sain Marie, and Seattle in the United Stat and from all cities in Canada from Victori British Columbia, to St. John, Newfoun land. This airline offers substantial savin in round-trip fares for groups of membe travelling from the cities it serves. Furthe information can be obtained from any of i agents, or from the AIEE Secretary in th American cities previously mentione American Airlines also serves Toronto fro many American cities or provides conne tions to cities served by other airlines. Th company also offers reduced fares to parti of 11 or more travelling together to Toront interested members should contact the local American Airlines office for detail

OF INTEREST TO UNITED STATES MEMBE

No passport or other document is require to enter or to leave Canada, and there is n entry fee or tax. Travellers returning the United States may find that Unite States immigration officers require proof identity and place of residence. Any of th following will prove satisfactory: an ol passport, birth or baptismal certificat voter's certificate, car license, driver license, or letter of identification from bank manager or a municipal officer. An document bearing signature and photograp may be used. Naturalized citizens shoul carry their naturalization certificates an nonnaturalized residents of the Unite States must have a re-entry permit issue by the United States Immigration an Naturalization Service.

Automobiles may enter Canada f personal transportation for a period up six months without payment of duty deposit. On reporting to customs at th Port of Entry, a permit for the car is mad out. State license cards should be carrie On leaving Canada a car must be cleare through Canadian customs.

Golf sets, camera equipment, slides slide films, and samples or other apparat being brought into Canada for the purpo of demonstrations during the meeting shoul be declared at the border crossing poi to *both* the United States and Canadia Customs Officers. This is important facilitate the re-entry of this material in the United States.

The Sunday following the completion the meeting is Dominion Day in Canad which will be celebrated on Monday, July and Wednesday, July 4, is of course, Ind pendence Day in the United States. Mem bers may wish to take advantage of the additional holidays to extend their trip include a visit to the vacation districts Muskoka and the Georgian Bay, which a within an easy half-day's drive from Toront

acific General Meeting Sessions To Stress Power, Forest Product Industries

Arrangements are being completed under e guidance of C. B. Carpenter as Chairman d M. M. Ewell as Vice-Chairman for the IEE Pacific General Meeting to be held at e Multnomah Hotel in Portland, Oregon, onday through Thursday, August 20 rough 23. The plans promise a well-unded program with pertinent technical ssions, many inspection trips, and sufficient tertainment for a very fine meeting.

The Technical Papers Committee, under e direction of W. E. Enns, Chairman, has ranged a full program designed to emphaze the advancements made in power indusy as well as the forest product industries of e Northwest. These major industries nbrace almost all phases of electrical engieering including communications, measureents, industrial heating, power generation d transmission, and so forth.

The nearness of Portland to both the Unirsity of Oregon and Oregon State College, well as many universities and colleges in e city of Portland and surrounding area, ould make for a very active student parcipation. A student technical papers seson has been scheduled, and a large student tendance is expected from the entire area.

Portland, known as the "City of Roses," ill provide an ideal location for this always opular meeting. Portland is a city of disnctive beauty and charm on the banks of e Willamette River, near that stream's nfluence with the Columbia River. These vers, flowing approximately 100 miles to e sea, bring ships from the world's maritime ations to Portland's own midtown docks. s location in the heart of great stands of evereen timber, rich agricultural and livestock nds, plus a fast-growing hydroelectric power ea, makes Portland a city of particular terest to the entire electrical industry. ortland is the center of the Pacific Northest's vast hydroelectric resources, possessing) per cent of the potential water power of e United States. At the present time, the mbined capacity of the private, municipal, d government power systems, which are tegrated into the large Northwest power ol, is over 4,000,000 kw.

INSPECTION TRIPS

An interesting and varied program of spection trips which will include trips to any local and nearby industrial plants, portant nearby power plants and substaons, and some educational facilities has en arranged by the Inspection Trip Comittee, with O. A. Demuth as the Chairman. l-day inspection tours have been planned r Thursday and Friday, August 23 and 24, r those installations of importance at longer stances from Portland.

Portland is in the heart of the West's forest oducts industries, and tentative plans are ing made to inspect typical plywood and rdboard plants, as well as the Crown llerbach Paper Mill in Camas, Wash. so planned is a trip through the large eyerhaeuser Lumber Company plant in ngview, Wash. Inspection trips to power cilities include trips to the Bonneville Dam wer House located 40 miles east of Portnd on the Columbia River. This dam has created a lake 50 miles upstream and with its navigation lock, the world's largest single-lift lock, has made navigation possible by ocean ships to The Dalles, 200 miles from the sea. Other power installations to be visited are Pacific Power and Light generating plants on the Lewis River; the Ross Substation and Microwave installation of the Bonneville Power Administration; local substations of Pacific Power and Light and Portland General Electric Company; the Bonneville Power Administration 230-kv series capacitor installation at Chehalis, Wash.; and the McNary Dam, to which an air trip is tentatively scheduled. Of the aluminum plants in the vicinity, it is planned to visit the Aluminum Company of America plant and wire mill in Vancouver, Wash. Other trips of interest may be made to the High-Voltage Laboratory at Oregon State College and the heat pump installation in the local Equitable Building.

View of Portland, Oreg., with Mt. Hood, the highest point in the state, in the distance

ENTERTAINMENT

The evening entertainment program will be highlighted by the main banquet on Wednesday, August 22. A President's reception will be held on Monday evening, August 20. A program of interesting and enlightening movies has been scheduled for Tuesday evening, August 21. Other entertainment includes a golf tournament.

An enjoyable ladies' program has been arranged by the Ladies' Entertainment Committee, under the chairmanship of Mrs. W. Morgan Allen, including a tea, luncheon, and card party, and many sight-seeing trips. One trip will be to the beautiful 620-foot Multnomah Falls located 30 miles east of Portland on the scenic Columbia River Highway. This drive affords many views of majestic grandeur, and passes numerous state parks, United States Forest Service recreation areas, interesting rock formations, and a succession of eleven spectacular waterfalls. This trip will be long remembered.

Southern District Meeting and Student Branch Conference Held at Miami Beach

A 3-day meeting of the Southern District and a Student Branch Conference took place at Miami Beach, Fla., April 11–13, with headquarters in The MacFadden-Deauville Hotel. There were four technical sessions and two student sessions in the mornings. Inspection trips and sight-seeing tours were taken during the afternoons. Entertainment included a luncheon and a buffet supper and aquacade on Wednesday and a banquet on the following day. On the business side, an all-day meeting of the Board of Directors took place on Thursday, followed by a conference of student branch counsellors Friday morning. The registered attendance was 328 members and guests and 93 students.

OPENING SESSION

The feature of the opening session was a timely and constructive address on "What Can We Do About the Shortage of Engineers?" by President LeClair. He suggested as three steps toward the solution of this important problem the expansion of the facilities of technical institutes, training men on the job for specific semiengineering and engineering work, and taking stock of engineers in both civilian and military organizations who are not doing engineering work with the view toward shifting them to more essential pursuits. President LeClair also referred to the work of the Engineering Manpower Commission in connection with the problem. The address was published in *Electrical Engineering* in the May issue, pages 377–8.

Vice-President W. J. Seeley addressed the session and paid tribute to the committees which made the arrangements. He referred to the work of Professor P. H. Nelson in organizing the student activities of District 4 which has resulted in an increase in student enrollment during the past year.

The meeting was opened by H. F. Pierce, who extended a cordial welcome, as did Joseph Bronaugh, Chairman of the Miami Section.

AIEE President T. G. LeClair is congratulating Harvey F. Pierce, General Chairman of the Southern District Meeting, which was held in Miami Beach April 11–13. Joseph Bronaugh, Chairman of the Miami Section (far left), and AIEE Vice-President W. J. Seeley (far right) look on

LUNCHEON MEETING

At the well-attended luncheon meeting on April 11, R. B. Roberts, Vice-President of the Florida Power and Light Company, gave an address "There's More to Florida than Meets the Eye." Speaking in a humorous but pertinent vein, Mr. Roberts traced the phenomenal growth of Miami compared to other large cities. He also compared the growth of the county in which Miami is situated to the growth of Los Angeles County, Calif., under almost identical conditions before the industries had located. The extremely rapid growth of the Miami region was attributed to climate and the tourist trade. He referred to the second most severe depression in 1937 and concluded that an economy predicated on the tourists is sound as the revenue comes from all sections of the country. Through such indexes as bank deposits and gasoline sales, it has been found that summer business is increasing more rapidly than the winter business. In respect to the system of the Florida Power and Light Company, 450,000 kw of new units have been added since the war and by 1953 the system will have three times the capacity that it had at the end of the war.

Professor F. H. Pumphrey, Chairman of the Florida Section, acted as toastmaster. He stressed the opportunities and inspiration which the Institute offers to meet prominent men in the industry.

STUDENT ACTIVITIES

Student activities began April 9 with registration at the University of Florida; 93 delegates registered. Guided tours were conducted through the new Engineering and Industries Building as well as to all of the facilities of the Engineering Department, laboratories, equipment, and classrooms. A banquet was held in the evening which was addressed by Joseph Weil, Dean of the College of Engineering, and entertainment was provided later. Wednesday evening there was a dinner and dance sponsored by the Engineers Club of Miami at the University of Miami.

Thirteen technical papers were presented by the students in two morning sessions—one on April 11 and one on April 12. The papers were of excellent caliber and the judges had a difficult time determining the winners of the prize awards. The winners were announced at the banquet on Thursday evening (see the following section on the Banquet for the names of the winners).

On Friday morning, a brief business meeting was held to decide on next year's activities.

During the afternoons, many of the students went on the inspection trips and sight-seeing tours scheduled on the program. Each day they put out a paper of their activities called "High Tension," which contained interesting data on the electrical industry extracted from the Edison Electric Institute statistical bulletins, *Electrical Merchandising*, and the United Nations statistical bulletins.

BANQUET

The banquet was held on Thursday evening, with entertainment following the dinner. Vice-President Seeley announced the winners of the Student Paper Prize Awards:

First Prize: **A Photoelectric Congestion Indicator,** *William D. Windley,* University of North Carolina

Second Prize: **Safety Through Electronics,** *Eugene C. Pauly,* University of Florida

Third Prize: **Magnetostrictive Dental Drill.** *James M. Hoylman, Jr.,* University of Virginia

TECHNICAL SESSIONS

Four technical sessions—two General Groups and two Power Groups—were held on Thursday and Friday mornings.

General Group—April 12. At the first session, with J. O'D. Shepherd and R. J. Cooper presiding, a paper was presented by R. C. Cheek, Westinghouse Electric Corporation, which dealt with the application of microwave channels. The author gave a number of the factors that must be taken into consideration in the establishment of a microwave channel, such as the selection of the frequency bands, selection of the sites for the terminals, calculation of the free-space loss between the antennas, and the calculation of other losses between the transmitting and receiving equipment and the antennas.

The second presentation, by I. S. Coggeshall of the Western Union Telegraph Company, explained how Florida was the communication gateway to the Caribbea The author emphasized the importance ar moral obligation of keeping these channe of communication open.

The third paper dealt with telegra handling by facsimile and was presented b H. H. Haglund of the Western Union Tel graph Company. The author described th steps leading up to the development of th Desk-Fax machine and the central offi equipment required. Transmission and r ceipt of an actual message on the Desk-F was demonstrated. The author stated th there are 2,000 machines already install in 11 different cities. One thousand mo would soon be installed in Washington an by the end of the year some 2,000 mo would be installed in 14 other cities.

The fourth presentation, which w illustrated with movies, was by M. I Latour of the University of Florida. H explained how radar is used for the locati of hurricanes and other weather phenome such as cold fronts. Mr. Latour said th the data furnished to the Weather Burea served as a basis for a new theory on th formation of tornadoes.

Some recent developments in loran we described by A. W. Sullivan of the Un versity of Florida. The frequency has bee lowered to 100 kc which has increased th range 1,200 to 1,500 miles. The auth explained that they were constantly strivin for a completely automatic system whi will reduce the time required to obtain a fi

F. O. Nottingham, Jr., of the Georg Institute of Technology described in h paper a low-frequency polar vector indicat which is useful in stability studies of serv mechanisms in conjunction with feedba amplifiers and other automatic contr devices.

The last paper was presented by J. Dexter of the Dow Corning Corporatio The author described the characteristics ar physical properties and some of the speci applications of silicone rubber, a resilie dielectric.

General Group—April 13. M. A. Honn and H. C. Uhl presided at the Frid morning session. In the opening paper, th results of electric home heating in th Nashville area were discussed by E. E. Par of the Electric Power Board of the city Nashville. The author explained a servi which his company has inaugurated to ma every electric heating job a satisfactory on Estimates are made of the heating requir ments and the annual heating bill and re ords have been kept for most of the ele trically heated homes. The subject w discussed in the light of the higher cost other fuels since the war and the possibili of this type of load becoming desirable fro the power company's point of view.

In another paper, A. C. Gibson of t Nashville Electric Service described the co struction and installation of electric stea and hot water accumulators and th operation from a maintenance point view.

In another heating paper, H. A. Ow of the University of Florida discussed t theory and design of work coils for hi temperature induction heating of nonma netic metals which has application connection with aircraft and guided missi at supersonic speeds and the need simulated facilities for testing on the grou

A new method to determine instantaneous rrents and voltages by employing alpha, ta, and zero components was presented Miss Edith Clarke of the University of exas. The use of the method was illusated in the case of a line-to-line short rcuit by substituting in Parks' equations r an ideal synchronous machine and lving. Another illustration of application as given in the case of opening a 3-phase ult when all three phases do not open at e same instant. Miss Clarke emphasized at the method is one which is very much orter and that it was not a substitute for mmetrical components.

In the field of industry, an interesting alysis of performance and the intricate ntrols required for a modern sectional ectric paper machine was described by . M. Baker of the Westinghouse Electric orporation. In another paper, Clarence . Grund, Jr., of the Alabama Polytechnic stitute traced the history of the development of the amplidyne and he discussed e theory.

In the field of lighting, the importance of od street and highway lighting was rikingly emphasized by R. J. Swackhamer f the General Electric Company. With e aid of National Safety Council statistics nd with the cost of each death placed at 82,000, as well as the increased number f accidents during the dimout in 1941 and 942, the speaker emphasized that the loss f 24,000 lives per year justifies any amount f expenditure for good street and highway ghting.

In a paper entitled "The Bare Facts of ight," H. L. Logan of the Holophane ompany, Inc., explained with the aid of harts and nomograms how good archiectural lighting can be attained for various special purposes in accordance with the efficiencies desired.

INSPECTION TRIPS

During the meeting inspection trips and sight-seeing tours were arranged in the afternoons to the Cutler Steam Electric Station of the Florida Power and Light Company, the United States Weather Bureau, television station WTVJ, a boat tour on Biscayne Bay, and a tour of greater Miami, as well as a visit to the shops of the Eastern Airlines at the International Airport and a 30-minute flight over the city.

LADIES' ENTERTAINMENT

In addition to the scheduled events for members, special ac ivities were arranged for the ladies. On Wednesday there was a visit to Gulfstream Park in Hallandale and a luncheon. On Thursday a visit was made to shops on Lincoln Road, and on Friday an informal "Hibiscus Brunch" was held on the Beach Terrace of the MacFadden-Deauville Hotel.

COMMITTEES

Members of the General Committee which made the arrangements were: *Chairman*, Harvey F. Pierce; *Co-chairman*, Ollie T. Ayers, Jr.; *Treasurer*, Clyde V. Booth; *Finances*, E. F. Johnson; *Publicity*, C. K. Lingo; *Hotels and Reservations*, R. L. Poor; *Transportation and Inspection Trips*, J. W. Beville, Jr.; *Student Branch Co-ordinator*, Professor Frank Lucas; *Information*, R. A. Goodburn; *Programs*, J. W. Lacy, Jr., and C. H. Summers; *Technical Papers*, Dr. H. H. Sheldon; *Ladies' Entertainment*, Mrs. O. T. Ayers, Jr.; *Sports and Entertainment*, C. W. Cogburn; *Tickets*, C. M. Broom; *Signs*, George H. Shipley.

Papers on Static Electricity Given at 1-Day AIEE Textile Conference

Static electricity and good installation ractice were the general subjects condered at the 1-day Textile Conference North) held in Philadelphia, April 23, 951, at the Engineers' Club. The seven apers presented were concerned with roblems of great interest to the 84 engineers ttending, as was evidenced by the lively iscussion which followed the papers' eading. The conference was sponsored by e AIEE Textile Subcommittee, the Philaelphia Textile Institute, and the AIEE hiladelphia Chapter.

The Chairman of the AIEE Textile Comittee, R. J. Demartini, introduced B. W. ayward, Director of the Philadelphia extile Institute, who welcomed the visitors nd told something about the school of hich he is head and the technical problems n which they are working. The first paper, Principles of Static Electricity," was given y L. E. Walkup, Battelle Memorial Initute. This laid the groundwork for the ext two papers, as the author demonstrated e generation and elimination of static ectric charges and explained the difference etween triboelectrification (contact) and duction electrification. This was followed y demonstrations of how static can be eliminated by ionizing the air by flame, ultraviolet light, the use of sharp points or wires, and the emanations from radioactive materials.

Mason Hayek, E. I. DuPont de Nemours and Company, read "Static Electricity on Synthetic Fibers and Fabrics." He chose nylon as an example of a synthetic fiber and fabric and demonstrated how an antistatic agent applied to either sliver or woven material reduced static to a point where it was practically negligible. He told about the electrostatic series according to Lehmicke, which lists materials according to their positive or negative charge when brought in contact with one another. Starting at the positive end, the series lists glass, human hair, nylon, wool, silk, and so forth, down to Orlon, Saran, and polythene at the negative end. Surface conductivity and moisture content of textiles are related to the static charge, that is, the greater the moisture, the smaller the charge. In line with this fact, the speaker described apparatus used to measure electrostatic properties of cloth with and without antistatic agents.

The final paper of the morning session, "The Influence of Static Phenomena on the Textile Processing of Wool," was presented by L. A. Runton of the M. T. Stevens and Sons Company. In the early stages of wool processing, the wool is sprayed with an oil-water emulsion and no static is experienced; however, the material is rapidly dried and when the web leaves the first breaker card, enough static has accumulated in many cases to cause drooping or cause holes in the sheets. Static gives most trouble in the finisher, as there is a rubbing action of the apron. In making worsteds, trouble is often experienced in withdrawing the sliver from the can: the accumulation of static charge sometimes is evidenced by a veritable bursting of the sliver and even breaks. In spinning, warping, winding, and weaving, the yarn often becomes uncontrollable, although in the latter process the humidification of weave rooms at levels about 65 per cent at 75 degrees Fahrenheit has greatly reduced static troubles at the loom.

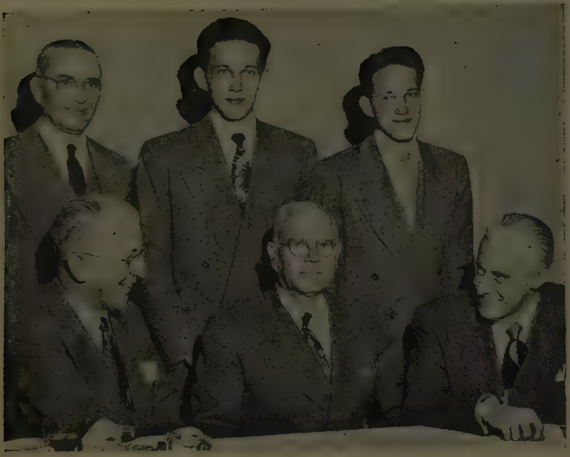
Analysis of the locations on woolen and worsted machinery where static causes trouble shows that in general when the fibers, webs, sliver, or yarns are loose or lying flat on an apron or tape the static influence is disruptive. This may lead to additional aprons or other devices being added to avoid such trouble; however, this is impractical in most instances. Further study is suggested along these lines as the highly charged material may cause a fire, especially during the dry winter periods.

The first paper of the afternoon session was read by Swaffield Cowan, Factory Insurance Association, and dealt with "Fundamentals of Good Electrical Installation Practice." Obsolete electric equipment is a fire hazard, both indoors and outdoors. As an example, inside a cotton mill fly is found in places where it would never be suspected that it would penetrate and such accumulations are fire hazards. The National Electrical Code of 1951 has new requirements for equipment by means of which such accumulations will be prevented. A request was made by the speaker for comments on these new enclosures after examination of the new Code.

"Wiring the Loom" was the subject of the next paper presented by Victor Sepavich, Crompton and Knowles Loom Works. One of the earliest electrical components added to a loom was the drive motor, little or no attention being given to the safety aspects of the wiring, switches, and so forth. Different types of trouble developed: open-type motors burned out due to accumulations of lint and oil; solid-wire leads broke because of the fatigue due to vibration; wire insulation deteriorated because of oil leakage, causing short circuits and fires. In the course of years, these troubles have been overcome by the improvement of components, such as totally enclosed motors, oil-resistant covered cables, the use of stranded wire instead of solid, and new switch enclosures.

With the increase in loom speed and number of hours of operation, improvements became necessary in the components of the warp stop motions. Solid wires crystallized and broke; oil attacked the wires' rubber insulation; lint collected around drop wires and warp-stop contact bars and often ignited when an arc was drawn from the drop wires. Hairy or uneven warps prevented the drop wires from

Lehigh Valley Section Hears About Leadership Shortage



**J. C. McKeon, manager of university relations for Westinghouse Electri
Corporation at East Pittsburgh, addressed members of the AIEE Lehig
Valley (Pa.) Section at a dinner meeting at the Hotel Bethlehem in Bethle
hem, Pa., April 13. Mr. McKeon spoke about the critical shortage o
scientific and professional leadership that faces the nation. He said
"Whether we as a nation experience a series of Koreas, all-out war, or
period of uncertain peace, we must maintain a state of total preparednes
Failure to train and properly utilize our greatest asset—potentia
leaders—would be national suicide." A student paper on "Mechani
cal Filters" was presented by Lawrence A. and Gerald D. Hohmann
twin brothers and senior electrical engineering students at Lehigh Uni
versity. Left to right, seated, are: Chairman George M. Keenan
District Manager Floid M. Fuller, and J. C. McKeon. Left to righ
standing, are: Vice-Chairman D. A. Campbell, Jr., Lawrence A
Hohmann, and Gerald D. Hohmann**

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settling solidly on the contact bars, permitting the loom to run for several picks even after a warp thread was broken. These troublesome conditions have been remedied to a great extent.

Another great increase in loom wiring variations was the electric feeler applications, of which two types are in general use, the most common being the double-prong type. In operation, the feeler is held stationary and the bobbin contacts the prongs during the forward motion of the lay, these prongs being set so that they are pushed backwards by a depleted bobbin. As loom speeds increased, contacts were made and broken very rapidly due to the prongs "bouncing" with the result that inductive arcs were produced with a resulting pitting of the prong tips, as in the warp stop, and a time delay in establishing the circuit. This trouble was reduced by the substitution of a smaller solenoid in the circuit with other circuit changes which reduced the inrush currents.

L. J. Marburger, Berkshire Knitting Mills, presented "Electrical Installations on Full Fashioned Hosiery Machines." The author analyzed the methods of testing the electrical drives of hosiery machines, which are peculiar to this type of knitting machinery and its operation. Preventive maintenance of the electrical drives and their attendant controls and panels proved well worth while over the course of years.

The final paper of the conference was given by Dan McConnell, Cone Mills Corporation, and was entitled "Finishing Plant Electrical Installation Problems." The author outlined the various factors peculiar to a finishing plant which should receive careful consideration during the designing stage, or when the plant is undergoing changes. For example, since finishing plants are large users of heat, the steam facilities should be given consideration, as it is usual for a considerable portion of the electricity to be furnished by bleeder turbines. The design of the steam power plant offers nothing unusual except that thought should be given to the reliability of both the steam and electric equipment. In this connection, studies should be made of the breakdown service available from nearby utilities, company-owned or public.

The basic power pattern of a finishing plant should be one that is some variation of the load-center distribution method, for here the high-voltage distribution can be arranged in any orthodox manner with either overhead lines or underground cables delivering to outdoor transformers feeding low-voltage power to switchgear mounted in rooms cut off from the rest of the plant and suitably ventilated. Another factor is the conduit installation and the wiring it contains. Ambient conditions, both of
temperature and humidity, must be car
fully considered in choosing the insulatin
materials to be used.

A 2-day Textile Conference (South
was held at the Georgia Institute of Tec
nology in Atlanta, Ga., April 26–27, an
was attended by approximately 140 eng
neers. The three papers on static electricit
presented at the morning session of th
Philadelphia conference were also read
the Atlanta meeting, and five other pape
were given.

Answer Your Questionnaire on Technical Division Publications

To conduct more effectively the technical activities, the Institute for several years has been organized in five major technical divisions: communications, general applications, industry, power, and science and electronics. The areas encompassed by each division are defined most readily by a listing of the technical committees in each of the divisions. This has been done on the reverse side of a questionnaire on technical division publications recently sent to all members. For convenience, the questionnaire has been made up in five parts.

With respect to Part 1, the Technical Advisory Committee would like to know the major interests of members in each division so that announcements of technical conferences on certain subjects might be most effectively sent to those interested. Please indicate by the number 1 the technical field in which you are primarily interested. Also, please indicate your interest in the other divisions in the order of preference by the numbers 2 to 5.

With regard to Part 2 and the high degree of specialization that exists in the electrical industry today and the technical work organized in five major divisions, it seems logical to correlate the technical papers in the five divisions according to subject matter. Such divisional publications bound in paper covers would be issued three or four times a year and take the place of the present AIEE
Proceedings (individual pamphlets of eac
paper and the discussion). The Publicatio
Committee is making an extensive study
the matter which might result in a mo
efficient method of distributing the technic
material. However, before a specific pla
can be worked out and exact costs dete
mined, it is necessary to know how man
copies of each divisional publication wou
be required. In the proposed plan, eac
member could elect to receive one division
publication three or four times a year fre
Other divisional publications might be pu
chased at a nominal annual subscripti
rate, presumably in the range of $2 to $
Please check the **one** division you would ele
to receive free. Please check the oth
divisions to which you would subscri
annually at $2 to $3 per division.

Part 3 is related to Part 2; please che
your preference for the proposed plan
divisional publication or continuance of t
present policy of issuing AIEE *Proceedings*.

With regard to Part 4, inasmuch as
survey had to be made to resolve the previo
questions, it would be very helpful to kn
the occupational functions of the memb
ship in planning an annual publicati
program as well as from the point of vi
of advertising sales promotion. A gr
many more technical contributions are
ceived during the year than can be acco
modated within the space available.

ow the occupational functions of the embers would be helpful as a guide in ecting the proper proportions of certain bject matter in relation to the interests of ost members. Please check your more important occupational functions.

Last but not least, please print your company name and city address as well as title Part 5. These are important in helping formulate a publication program to meet e needs of the most members.

The success of such a survey depends upon ch member's carefully filling in all five rts of the Technical Division Publications uestionnaire. This will only take a few inutes of your time. A return postage-paid welope accompanied the questionnaire for nvenience. **If you have not already eturned your answers, do it now!**

amme Medal Nominations for 1951 Due December 1

Special attention is directed to the fact at the names of Institute members who e considered eligible for the AIEE Lamme Iedal, to be awarded early in 1952, may e submitted by any member in accordance ith section 1 of article VI of the bylaws f the Lamme Medal Committee, as follows:

> "The committee shall cause to be pubshed in one or more issues of *Electrical ngineering*, or of its successors each year, referably including the June issue, a stateent regarding the Lamme Medal and an vitation for any member to present to the ecretary of the Institute by December 1, e name of a member as a nominee for the edal, accompanied by a statement of is 'meritorious achievement' and the names f at least three engineers of standing who re familiar with the achievement."

Each nomination should give concisely e specific grounds upon which the award proposed, and also a complete detailed atement of the achievements of the nominee, enable the committee to determine its gnificance as compared with the achieveents of other nominees. If the work of e nominee has been of a somewhat general haracter in co-operation with others, ecific information should be given reарding his individual contributions. Names f endorsers should be given as specified in e foregoing quotation.

orth Eastern District Meeting Held in Syracuse, N. Y., May 2-4

A successful 3-day meeting of the North astern District held in Syracuse, N. Y., on Iay 2–4 had just concluded when this issue ent to press. A more complete report on e various phases of the meeting will be ublished in the July issue of *Electrical ngineering.*

Six technical sessions were held on the ubjects of street lighting, computing devices, ower generation (two sessions), electronics nd communications, and air conditioning. wo student sessions were held May 4 and apers were presented by the students from e branches in the district. The District Branch Paper Prize was awarded to Ernest Codier of Syracuse University for his paper entitled "Piezo-Electric Clutch." The Graduate Paper Prize was awarded to Charles Lenz, Massachusetts Institute of Technology, for his paper "Less Time for Time Constants."

The smoker was held on Wednesday evening and the banquet on Thursday. One of the important features of the meeting was a timely address, "Engineering—Its Future" by A. C. Monteith, Vice-President in Charge of Engineering of the Westinghouse Electric Corporation. The speaker reviewed the critical shortage of engineers in relation to the defense program, the steps being taken by the Engineering Manpower Commission of Engineers Joint Council to help the situation, and the need to impress on the public the fact that in modern warfare the man in production is just as important as the man on the front line. Another feature of the meeting was a round-table presentation on the topic "The Assignment and Development of the Engineer as a Professional Man," in which well-qualified speakers from the fields of industry and education expressed their views.

District 3 Student Branch Meeting Held in New York City

A Student Branch Meeting of District 3, sponsored by the New York Section of the AIEE, was held in New York, N. Y., May 4 in the auditorium of the Western Union Building with 189 attending from the colleges in the New York area. Seven papers were submitted by the students from which four were chosen for oral presentation, and the judges had a difficult time determining the prize awards from among the excellent papers.

The meeting, presided over by Vice-President C. S. Purnell, was opened by Walter P. Marshall, President of the Western Union Telegraph Company, who extended a cordial welcome to all present, and gave an interesting account of the growth and scope of Western Union.

Following a luncheon, the winners of the Prize Awards were announced as follows:

First Prize, $25. The Principle and Application of Medar, *Fred W. Jacob*, Manhattan College

Second Prize, $10. Design and Construction of a 35,000-Volt 115-Watt Regulated Power Supply, *Mathew Kabrisky*, Polytechnic Institute of Brooklyn

Third Prize, Evaluation of an Eastern College Electrical Shop in Terms of its Present and Future Duty, *Carl Flick*, Polytechnic Institute of Brooklyn

An interesting and educational demonstration lecture on "Electronics and Light, Giant Twins of Tomorrow" was given by S. G. Hibben, Director of Applied Lighting, Lamp Division, Westinghouse Electric Corporation.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Communication Switching Systems Committee (*R. C. Davis, Chairman; John Meszar, Vice-Chairman; A. E. Frost, Secretary*). This committee had a well-attended meeting on January 24, 1951, to discuss the possibilities for communication switching sessions at the 1951 Fall and 1952 Winter General Meetings.

It was concluded that the general interest in a symposium of papers on community dial office switching at the Oklahoma City meeting last fall warranted continuing this subject at the 1951 Fall meeting. A number of promising suggestions were made and it now appears that papers relating to community dial office problems can be presented at the Cleveland Fall meeting.

An especially interesting program is planned for the 1952 Winter meeting. One of the most important and interesting developments in communications switching over the past few years has been the development of the nation-wide operator toll dialing plan and in the technical developments needed to implement the plan. It is now expected that a symposium of papers on this subject can be presented at the 1952 Winter meeting.

Mr. D. L. Solomon, a member of the committee, has recently returned from a trip to Alaska where he had made a survey of the switching problems there for the Office of the Chief Signal Officer of the Army. Mr. Solomon told the committee of his trip and of the results of his survey.

General Applications Division

Committee on Air Transportation (*W. V. Boughton, Chairman; D. E. Fritz, Vice-Chairman; W. L. Berry, Secretary*). The committee plans to have a Special Technical Conference on Aircraft Equipment in Los Angeles, Calif., on October 8, 9, and 10, 1951, at the Hollywood Roosevelt Hotel.

The Aircraft Electrical Rotating Machinery Subcommittee, the Aircraft Electrical Systems Subcommittee, and the Electrical Control, Protective Devices, and Cable Subcommittee are reviewing the "Aircraft Electric Guide Report, AIEE *Standard Number 750.*" Revised drafts of certain sections of this report and new sections will be prepared for consideration by the Air Transportation Committee.

The Principle of Altitude Rating of Electrical Apparatus Subcommittee is in the process of circulating to the members of the subcommittee for comment a report on "Generator-Blast Air Cooling."

Industry Division

Subcommittee on Radiation Measurements above 300 Mc (*R. M. Baker, Chairman;*

Marvin Bock, Vice-Chairman; C. W. Frick, Secretary). Review of the proposed report, "Recommended Practice for Measurement of Electric Field Intensity Above 300 Mc from Radio-Frequency Industrial, Scientific, and Medical Equipments," was completed to the end of Section VII. It was felt that the remaining section (VIII) could be edited by Mr. Sorrows and Mr. Baker, who also would complete the lists of symbols and check the list of references. The report then would be ready for this Subcommittee to approve and submit to other AIEE committees for review and comments. This report includes the following Sections: Section I, Introduction; Section II, Symbols, Units, and Abbreviations; Section III, Methods of Measurement; Section IV, Antenna Design; Section V, Antenna Gain Measurements; Section VI, Associated Measuring Equipment; Section VII, Measurements on Production Equipment; and Section VIII, Measurement Precautions.

Power Division

Subcommittee on Magnetization Characteristics of Transformers (*J. E. Clem, Chairman*). This subcommittee has completed its work in connection with assigned subjects. Mr. Clem feels that the data which have been prepared are both worth while and informative. There are three working groups in this subcommittee: the first on Magnetization Characteristics of Transformers; the second relating to the Relay Problems Resulting from Excitation Characteristics of Transformers; and the third covering the Effect of Magnetizing Characteristics and Current on the Interrupting Ability of Air Break Disconnects. The detail data on the above have been submitted by the subcommittee to the main Transformer Committee as a progress report.

Committee on Rotating Machinery (*W. R. Hough, Chairman; C. G. Veinott, Vice-Chairman; J. L. Fuller, Secretary*). A new subcommittee is being formed, under the chairmanship of P. H. Trickey, to cover magnetic-fluid couplings and similar devices. Specifically, this committe is to cover magnetic-fluid clutches, the magnetic-particle clutch, the electric coupling, the eddy-current brake, the eddy-current dynamometer, and electrically operated friction brakes where the magnetic circuit is part of the brake itself. Excluded are electrically operated friction brakes in which the electrical part is simply a magnet or solenoid providing a pull which operates on the otherwise completely mechanical friction device. This is a fast-growing field and one which should produce a number of interesting papers and sessions in the next few years. Members having an interest in this field are urged to contact Mr. Trickey.

The other subcommittees are at work on a revision of the respective test codes. It is the intent to make these codes suitable for use directly in the American Standards Association *Standard C-50* on rotating electric machinery which is currently being revised. Wherever possible, reference is being made to AIEE Master Test Codes for temperature measurement, resistance measurement, and so forth, with the purpose of making the machinery codes concise while not sacrificing the availability of detailed discussions on methods of measurement.

Science and Electronics Division

Subcommittee on Electron Tubes of the Committee on Electronics (*H. C. Steiner, Chairman; D. E. Marshall, Secretary*). The subcommittee is co-operating for the second year with the Institute of Radio Engineers Committee on Electron Tubes and Semi-Conductors in the planning of the Electr Devices Conference. The subcommittee considering a conference on Electron Tub for Power Conversion similar to the one he in Buffalo in 1949 and joint sponsorship planned with the Electronic Power Co verter Committee and the Subcommittee Electronic Control. The subcommittee continuing active work on Standards f Mercury Pool Tubes. Plans have also be made for organization of a working group Standards for Radiation Detection Devic

AIEE PERSONALITIES....

O. E. Buckley (M '19, F '29), President, Bell Telephone Laboratories, Inc., New York, N. Y., has been named by President Truman to head a group of the nation's top scientists who will act on a science advisory committee to advise in matters relating to scientific research and development for defense. Doctor Buckley now becomes Chairman of the Board of Bell Laboratories. Born in Sloan, Iowa, on August 8, 1887, he graduated from Grinnell College in 1909 with a bachelor of science degree, and from Cornell University in 1914 with a doctor of philosophy degree in physics. He joined the Bell Laboratories in 1914 but his career was interrupted by service in the United States Army. He was placed in charge of the research section of the Signal Corps. He returned to Bell Laboratories in 1919 and continued his work on submarine telegraph cables. He also conducted research in the field of wire transmission. In 1927 he was appointed assistant director of research; in 1933, director of research; Executive Vice-President in 1936; and President in 1940. Since 1948, Doctor Buckley has served as a member of the General Advisory Committee of the Atomic Energy Commission. He was awarded the Medal of Merit for his services in World War II. Doctor Buckley has been a very active member of the Institute, serving as Vice-President of District 3 (1946–48), and on the following AIEE Committees: Electrophysics (1926–37, Chairman 1929–31); Basic Sciences (1946–48); Research (1934–40); Charles LeGeyt Fortescue Fellowship (1939–45, Chairman 1941–45); Finance (1946–47); Edison Medal (1944–49); Technical Program (1929–31, 1945–47); Executive (1946–48); and Communications a Science Co-ordinating (1947–48).

O. E. Buckley

C. R. Beardsley

C. R. Beardsley (A '08, F '30, Member f Life), retired, New York, N. Y., has be appointed chief of the power requiremen branch of the Defense Electric Power A ministration. He was born on December 1 1885, in Bridgeport, Conn., and was gra uated from the Sheffield School, Yale U versity, in 1905 with a bachelor of philosop degree in electrical engineering. M Beardsley served with the General Electr Company for six years and then with t United Illuminating Company, Bridgepo Conn., for a similar period. In 1918 went with Fred T. Ley and Compan Springfield, Mass., as electrical engineer charge of design and construction of pow and industrial plants. In 1923 he join the Brooklyn (N. Y.) Edison Company engineer in charge of electrical constructi and became affiliated with the Consolidat Edison Company of N. Y., Inc., when t New York and Brooklyn companies we merged in 1937. At the time of his reti ment in 1951 he was director of econon and industrial development. During Wo War II, he was loaned by his company the New York City Government to as in bringing defense industries to the N York area. He is an active member of t Institute, having served as Director (193 41) and on the following committe Edison Medal (1937–41); Legislation Affe ing the Engineering Profession (1937– Chairman 1939–41); Technical Progr (1937–41); Institute Policy (1940–42, Cha man 1941–42); Members-for-Life Fu

944–51, Chairman 1947–50); Board of aminers (1950–51); and on the Special mmittee on Registration of Engineers 942–46, Chairman 1942–46).

H. Schulz (A '37, F '50), Chairman, ectrical Engineering Department, Armour search Foundation, Technology Center, icago, Ill., has been named 1951 President the National Electronics Conference, c.; **W. G. Dow** (A '19, F '48), professor electrical engineering, University of Michi- n, Ann Arbor, Mich., has been named airman of the Board of the Conference; **A. M. Lyon** (A '38, M '47), assistant ofessor, Northwestern Technological In- tute, Evanston, Ill., has been appointed ecutive Vice-President; **H. J. McCreary** '24, F '46), consultant, Automatic Elec- c Company, Chicago, Ill., has been named cording secretary; **S. R. Collis** (A '48), gineer, Illinois Bell Telephone Company, c., Chicago, Ill., has been named chair- an, arrangements committee; **R. R. nness** (A '44), Electrical Engineering epartment, Northwestern Technological stitute, Evanston, Ill., has been appointed airman, housing committee; and **J. D. yder** (A '40, M '46), professor and Head, ectrical Engineering Department, Uni- rsity of Illinois, Urbana, Ill., has been med chairman, program committee.

P. Neubauer (A '27, M '46), division gineer, Electrical Engineering Depart- ent, Consolidated Edison Company of ew York, Inc., N. Y., has been elected airman of the New York Section of the EE. He is currently serving on the blic Relations Committee. **J. A. Parrott** '37), telephone engineer, American Tele- one and Telegraph Company, New York, Y., has been elected Vice-Chairman. e served the Institute on the Automatic ations Committee (1943–45). **J. R. erner** (A '40), central station division, estinghouse Electric Corporation, Newark, J., has been named treasurer.

R. Hewlett (A '40, M '47), Vice-Presi- nt, and **David Packard** (A '35), President, the Hewlett-Packard Company, Palo to, Calif., have made a gift in the name their company to Stanford University ich will enable it to construct a wing joining the new applied research center. is wing will be the center of electronics struction at the University. Since 1949, r. Hewlett has served the Institute on the V Broadcasting Systems Committee. Mr. ckard currently is serving the Institute on e Electronics and Instruments and Meas- ements Committees.

V. Kahler (M '39, F '46), Vice-President, inois Bell Telephone Company, Chicago, , has received one of the first Honor wards for Distinguished Service in Engi- ering from the University of Missouri, llege of Engineering. He was graduated m the University of Missouri in 1922 with bachelor of science degree in mechanical gineering. For two years following his aduation he was associated with the ll Telephone Laboratories, Inc., New rk, N. Y., and then in 1924 he became engineer in the General Engineering Department of the Illinois Bell Telephone Company. He was appointed successively to the following positions: division plant supervisor; chief engineer; and in 1943 he was named assistant Vice-President and general manager. Mr. Kahler is also a member of the Western Society of Engineers.

G. G. Boyle (A '46), field engineer, Sales Department, Micro Switch Division, Minneapolis-Honeywell Regulator Company, New York, N. Y., has been named branch manager of the New York office for the Division. He is an engineering graduate of the Newark College of Engineering. He joined the company in 1946, after having been previously employed by the Electric Boat Company. **Richard Destefano** (A '42), field engineer, Sales Department, Micro Switch Division, Minneapolis-Honeywell Regulator Company, Chicago, Ill., has been named branch manager of the Detroit office of the Division. He graduated from the Carnegie Institute of Technology and joined the Chicago office of the Division in 1945 where he held several sales positions before his latest promotion.

D. B. McKey (A '45), Partner, Dixie B. McKey and Associates, Washington, D. C., has been appointed a field sales representative for the Radio Corporation of America microwave and mobile communications products. Mr. McKey will supervise sales and installation of microwave equipment throughout the southern United States. His previous experience includes: serving on the technical staff of the American Telephone and Telegraph Company; from 1936 until 1944 he was general communications sales manager for Graybar Electric Company; and from 1944 until his recent appointment he was owner and operator of his own consulting radio engineering firm. Mr. McKey is also a member of the Institute of Radio Engineers.

R. I. Hanford (M '42), electrical engineer, and **E. W. Larson** (A '42), electrical engineer, both of the Ilg Electric Ventilating Company, Chicago, Ill., have been appointed head, Electrical Engineering Department, and engineer in charge of the electrical division, respectively. Mr. Hanford joined the company in 1914 as a draftsman. He later was in charge of the electrical engineering division, working on motor design. Mr. Larson became associated with the company in 1941 and worked under Mr. Hanford in the design and development of electric motors, specializing in single-phase motor design, development, and performance.

R. C. Freeman (M '44), engineering manager, welding divisions, General Electric Company, Fitchburg, Mass., has been named acting manager of the welding divisions. He joined the company in 1929, and shortly thereafter he was transferred to the Lynn, Mass., plant and was assigned to the motor engineering division. In 1936, he went to the welding section and in 1946 assumed the post of the division engineer of d-c welders at Fitchburg. He was named manager of engineering two years later. Mr. Freeman has served the Institute on the Electric Welding Committee since 1947.

J. Stanley Brown (A '23, F '50), electrical station engineer, Electrical Engineering Department, Duquesne Light Company, Pittsburgh, Pa., has been appointed electrical engineer. Mr. Brown has been electrical station engineer in charge of all Duquesne Light Company power station and substation electrical engineering and design since 1945. He has served the Institute on the Switchgear Committee since 1947. **Samuel Rosenbach** (A '23, F '48), general engineer, Electrical Engineering Department, Duquesne Light Company, Pittsburgh, Pa., has been appointed assistant electrical engineer. He has been active in transmission engineering since joining the company in 1922.

T. C. Pearce (A '22, M '37), superintendent, Substation Department, Potomac Electric Power Company, Washington, D. C., has been appointed general superintendent, Electric System. Mr. Pearce has been with the company for 30 years. **W. L. Hatton** (A '41, M '48), assistant superintendent, Substation Department, has been appointed superintendent. Mr. Hatton has been with the company since 1919. **J. R. O'Hanlon** (A '37, M '50), senior engineer, System Planning Department, has been made engineer assistant to the Vice-President in charge of operations.

J. G. Ausman (M '45), Vice-President, Southwestern Public Service Company, Amarillo, Tex., has been named Executive Vice-President; and **H. O. Hodson** (A '45), chief engineer, System Engineering Department, will replace Mr. Ausman as Vice-President and operating manager. Mr. Ausman has been connected with the Southwestern Public Service Company since 1928. He was transferred to Amarillo, Tex., as operating manager in 1944, and was made Vice-President in 1947. Mr. Hodson joined the company in 1938, and has been chief engineer since 1941.

J. V. McGuire (A '47), electrical engineer, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named engineer in charge of sales of the unit substation section. Following his graduation from Lehigh University in 1940, Mr. McGuire joined the company, working in its transformer, motor-generator, switchgear, and mixed apparatus sections. Until his new appointment, he was application engineer in the unit substation group.

A. G. Johnson (M '49), assistant chief engineer, Omaha Public Power District 936, Omaha, Nebr., has been promoted to the position of chief engineer. Mr. Johnson began his work with the utility in 1928 and his experience also includes that of field engineer, construction engineer, and underground engineer with the utility.

R. B. Steinmetz (A '26, M '48), manager, Marion Mill Sales, Anaconda Wire and Cable Company, Marion, Ind., has been appointed general manager of mills with headquarters at Hastings-on-Hudson, N.Y. Mr.

Steinmetz has been with the company since 1930 and his experience includes being district sales engineer in Boston and Cleveland. In 1941, he was appointed a special Washington representative for the company. In 1948, Mr. Steinmetz was made manager of the Marion mill.

L. J. Dunlap (A '36, M '42), sales engineer, Westinghouse Electric Corporation, Chicago, Ill., has been appointed as representative of the Chicago Section of AIEE to the Chicago Advisory Committee, Engineering Societies Personnel Service.

F. E. Nutt (A '36), district manager, Crocker Wheeler Division, Elliot Company, Chicago, Ill., has been appointed district manager of the Denver, Colo., office of the Elliot Company. Prior to his association with the Elliot Company, Mr. Nutt was employed for eight years by the General Electric Company.

R. P. Ballou (M '37), chief engineer, Federal Electric Products Company, Hartford, Conn., has been appointed chief engineer of the Howell Electric Motors Company, Howell, Mich. Mr. Ballou is a graduate of Iowa State College and his experience includes association with the Raytheon Manufacturing Company, Waltham, Mass., the Allen-Bradley Company, Milwaukee, Wis., and the Westinghouse Electric Corporation, East Pittsburgh, Pa.

E. W. Kimbark (A '27, F '48), professor of electrical engineering, Northwestern University, Evanston, Ill., has accepted a position as professor of electrical machinery at the Instituto Tecnologico de Aeronautica, Sao Paulo, Brazil. In addition to his new position he also will be acting head of the division of electronics of the Institute. He served on the AIEE Basic Sciences Committee (1950–51).

H. P. Steele (A '44), President, Benjamin Electric Manufacturing Company, Des Plaines, Ill., has been elected a Director of the American Standards Association. Mr. Steele has taken a leading part in standardization work for many years. Mr. Steele is also a member of the National Electrical Manufacturers Association and the Illuminating Society.

R. N. McCollom (A '47), central station sale supervisor, Westinghouse Electric Corporation, Detroit, Mich., has been given a year's leave of absence to aid in the nation's preparedness program. Mr. McCollom will work in the Power Equipment Division of the National Production Authority, Washington, D. C., in charge of the Switchgear Section.

R. W. Kunkle (A '49), manager, anchors and construction equipment sales, A. B. Chance Company, Centralia, Mo., has been appointed to the position of engineering manager. Mr. Kunkle holds an electrical engineering degree from Cornell University. He was associated with the General Electric Company before joining the A. B. Chance Company in 1948.

J. A. Green (A '42, M '49), electrical engineer, Dallas, Tex., has been appointed sales representative in the southwest territory for the Amperex Electronic Corporation, Brooklyn, N. Y. Mr. Green served the Institute on the Electronics Committee (1946–47). He is also a member of the Institute of Radio Engineers and the American Petroleum Institute.

R. J. Thompson (A '42, M '47), sales engineering manager, California Region, Trumbull Electric Manufacturing Company, North Hollywood, Calif., has taken military leave of absence from his position. He is on extended active duty as a major with the United States Air Force in the Directorate of Technical Inspection, Norton Air Force Base, San Bernardino, Calif.

G. R. Dayton (A '44), assistant sales manager, Cline Electric Manufacturing Company, Chicago, Ill., has been appointed general sales manager of the company.

G. A. Goddard (A '47), regional manager, Locke, Inc., Atlanta, Ga., has been appointed regional manager of the New York area for the company.

OBITUARY

Erroll Warren Allen (A '35, M '39), plant extension engineer, Southwestern Bell Telephone Company, Oklahoma City, Okla., died on February 21, 1951. He was born on March 29, 1896, in Russell, Kans. In 1923 he received a bachelor of science degree in electrical engineering from Kansas University and a law degree from the Dallas (Tex.) School of Law. His career with the Southwestern Bell Telephone Company began in 1923. After experience in Missouri and Texas, he was appointed plant extension engineer for Oklahoma in 1937. Mr. Allen was a past Chairman for the Oklahoma City Section of the AIEE and was National Vice-President of the 7th District of the AIEE, in charge of membership.

Maurice Charles Rypinski (A '03, M '13, Member for Life), retired, La Jolla, Calif., died on November 3, 1950. He was born in Giddings, Tex., on November 8, 1877. He was graduated from Rose Polytechnic Institute in 1897 with a degree of bachelor of science in electrical engineering. After graduation Mr. Rypinski became associated with the General Electric Company where he worked on electric testing apparatus and measuring instruments. In 1906 he joined the Westinghouse Electric Manufacturing Company (now the Westinghouse Electric Corporation) where he was the manager of the meter and transformer section of the Supply Sales Department. At the time of his retirement in 1947, Mr. Rypinski was Vice-President of the Kolster Radio Corporation.

Guy A. Moffett (M '44), assistant manager, industry control engineering division, General Electric Company, Schenectady, N. Y., died on March 27, 1951. He was
born on November 18, 1900, in Wainsvill
W. Va. He was graduated from We
Virginia University in 1924 with a bachel
of science degree in electrical engineerin
That same year he joined General Electr
as a student engineer on the Test Cours
and was transferred to the control divisio
a year later as a proposition engineer. H
was made a line engineer in 1928, and i
1939 became a section engineer. Followin
various supervisory positions, he was name
engineer of the divisions' industry divisio
in 1948. In 1950 Mr. Moffett was appointe
assistant to the manager of engineering f
the control divisions and held that post unt
his recent appointment to assistant manag
of engineering for the divisions. M
Moffett was also a member of the Associatio
of Iron and Steel Engineers.

Robert DeVere Hope (A '06, M '1
Member for Life), consulting enginee
Newark, N. J., died on March 23, 195
He was born in Richmond, Va., in 188
and was graduated from the Polytechn
Institute of Brooklyn (N. Y.) in 1907 wit
a degree of electrical engineer. Aft
graduation he worked with the New Yor
Bell Telephone Company in the Engineerin
Department until 1919 when he establishe
himself as an consulting engineer. M
Hope served in World War I as a captai
and served again in World War II i
Europe. He was retired in 1944 with th
rank of lieutenant-colonel. He was als
a member of the American Society of Mil
tary Engineers and the American Socie
of Mechanical Engineers.

James Reuben Raney (A '44, M '48
general meter superintendent, Georgia Pow
Company, Atlanta, Ga., died on March 2
1951. He was born in LaFayett, Ala., o
July 16, 1898. From 1920 to 1926, he w
a meter and relay tester for the Columb
Electric and Power Company, Columbu
Ga. For the next four years he was supe
intendent of service for the South Georg
Power Company, Albany, Ga., and in 19
Mr. Raney became associated with th
Georgia Power Company. He was Chairma
of the Georgia Section of the AIEE, and w
also a member of the Edison Electr
Institute.

Daniel Joseph Fleming (A '06, Memb
for Life), retired, Brooklyn, N. Y., died o
April 2, 1951. Mr. Fleming was born
Ireland in 1875. He attended Quee
College and came to the United States
1897. He was associated with the Gener
Electric Company from 1902–04, wi
Allis-Chalmers Manufacturing Compa
from 1905–08, and with the Westinghou
Electric Manufacturing Company (now th
Westinghouse Electric Corporation) fro
1909–11. He was also chief engineer
charge of construction and operation f
Tucaman, Argentina. Before his retireme
Mr. Fleming was connected with the Publ
Service of New York State.

Daniel Macfarlane Fraser (M '17, F '2
Member for Life), President and gene
manager, D. M. Fraser, Ltd., Toront
Ontario, Canada, died on January 20, 195

was born on April 15, 1879, in Edingh, Scotland, and was graduated from iot Watt College with a diploma in trical engineering. He came to Canada 910 and for several years he was employed n estimating engineer for the Canadian eral Electric Company. In 1921 he blished the D. M. Fraser Company. Fraser was also a member of the Proional Engineers of Ontario and the gineering Institute of Canada.

liam **Lasko** (A '48), electrical mainance foreman, Caterpillar Tractor Comy, Peoria, Ill., died on April 8, 1951. was born on May 12, 1892, in Decatur, He was associated with the Wabash lroad from 1913–22 and in 1928 became nected with the Caterpillar Tractor mpany. He was made foreman in 1940.

EMBERSHIP • • •

commended for Transfer

he board of examiners at its meeting of April 19, , recommended the following members for transo the grade of membership indicated. Any objecs to these transfers should be filed at once with the etary of the Institute. A statement of valid reasons such objections, signed by a member, must be ished and will be treated as confidential.

Grade of Fellow

han, O., transmission & substation engr., Public Service Electric & Gas Co., Newark, N. J.
k, A. L., retired, 14 Ashland St., Worcester, Mass.
ards, G. D., director of quality assurance, Bell Telephone Labs., Inc., New York, N. Y.
, D. G., editor-in-chief, *Electronics*, McGraw-Hill Publishing Co., New York, N. Y.
, H. A., mgr. of engg., Locke Incorporated, Baltimore, Md.
steen, H. B., prof. of elec. engg., The City College of New York, N. Y.
bsen, W. E., asst. mgr., federal & marine engg. div., General Electric Co., Schenectady, N. Y.
es, C. A., asst. to elec. engr., Public Service Co. of Northern Illinois, Chicago, Ill.
s, R. A., district mgr. of engg., General Electric Co., New York, N. Y.
Motte, W. R., genl. supt. of generation, Public Service Electric & Gas Co., Newark, N. J.
le, L. J., consulting engr., Allis-Chalmers Mfgr. Co., Hyde Park, Mass.
Coy, R. L., chief design engr., Locke Incorporated, Baltimore, Md.
Farlane, M. L., consulting engr., Box 192, Sierra Madre, Calif.
Farlin, J. R., vice pres., Elec. Service Manufacturing Co., Philadelphia, Pa.
rson, E., member of technical staff, Bell Telephone Laboratories, New York, N. Y.
e, A. F., engineer, American Tel. & Tel. Co., New York, N. Y.
sell, J. B., Jr., professor of elec. engg., Columbia University, New York, N. Y.
er, E. H., research engr., Electrical Testing Laboratories, Inc., New York, N. Y.
noff, D., chairman of board, chief executive officer, Radio Corporation of America, New York, N. Y.
lby, R. E., director of television technical operations, National Broadcasting Co., Inc., New York, N. Y.
tt, C. C., mgr., small motor div., Westinghouse Electric Corp., Lima, Ohio
ger, F. J., director of switching engg., Bell Telephone Laboratories, New York, N. Y.
der, L. S., mgr., transformer div., Westinghouse Electric Corp., Sharon, Pa.
ight, H., special project engr., Anaconda Copper Mining Co., New York, N. Y.
dup, A., director of military communications engg., Bell Telephone Laboratories, New York, N. Y.
d, E., supt. of power supply, Commonwealth Edison Co., Chicago, Ill.
liams, E. C., mgr. power supply, Public Service Co. of Northern Illinois, Chicago, Ill.

o grade of Fellow

Grade of Member

ck, G. W., chief engr., John A. Roebling's Co., Trenton, N. J.
ess, M. C., chief engr., A. J. F. Industries, Inc., Brooklyn, N. Y.
ala, J. B., asst. prof. of elec. engg., Pratt Institute, Brooklyn, N. Y.
Alexander, D. C., asst. prof., Worcester Polytechnic Institute, Worcester, Mass.
Baker, F. E., mgr. specialty transformer dept., Westinghouse Electric Corp., Sharon, Pa.
Ball, C. E., elec. engr., technical studies div., Sao Paulo Tramway Light & Power Co., Ltd., Sao Paulo, Brazil
Barton, H. J., Jr., elec. engr., St. Louis County Water Co., University City, Mo.
Bednarz, F. J., asst. head, guidance & control div., U. S. Naval Ordnance Test Station, Pasadena, Calif.
Bell, P. M., electrical service supervisor, Westinghouse Electric Corp., Philadelphia, Pa.
Biester, W. H., Jr., pres., Electro Construction Co., Philadelphia, Pa.
Biggs, H. C., staff member, Sandia Corp., Albuquerque, New Mex.
Brangan, C. S., owner, Bra Bon Electric Co., Bala-Cynwyd, Pa.
Buck, J. R., petroleum engr., DeGolyer & MacNaughton, Consultants, Dallas, Tex.
Bunton, G. R., div. general supt., Southwestern Public Service Co., Lubbock, Tex.
Burns, L. L., Jr., research engr., RCA labs. div., Radio Corporation of America, Princeton, N. J.
Campbell, J. S., Jr., senior designer, NEPA div., Fairchild Engine & Airplane Corp., Oak Ridge, Tenn.
Caplan, R. S., elec. engr., HPL div., Gulf Refining Co., Houston, Tex.
Case, R. D., Jr., consulting & application engr., Westinghouse Electric Corp., Philadelphia, Pa.
Cole, B. R., elec. engr., Raytheon Manufacturing Co., Waltham, Mass.
Conner, J. O., district plant supt., Southwestern Bell Telephone Co., Lawton, Okla.
Connor, H. F., Jr., instructor, University of Michigan, Ann Arbor, Mich.
Cooper, R. J., protection engr., Georgia Power Co., Atlanta, Ga.
Cottrell, G. L., assoc. prof. of elec. engg., Cornell University, Ithaca, N. Y.
Cree, J. G., mgr. of utilities, Borough of Chambersburg, Chambersburg, Pa.
de Freitas, J. S., chief, technical div., Sao Paulo Tramway Light & Power Co., Ltd., Sao Paulo, Brazil
deGruy, W. V., asst. elec. engr., New Orleans Public Service, Inc., New Orleans, La.
DiIorio, F., Jr., elec. engr., Burns & Roe, Inc., New York, N. Y.
Drake, C. J., elec. engr., Phillips Petroleum Co., Phillips, Tex.
Dummer, R. A., engr. chge. of test, Pennsylvania Transformer Co., Canonsburg, Pa.
Dyer, G. L., district engr., Southwestern Bell Telephone Co., Tulsa, Okla.
Ehrhardt, J. I., supervisor of elec. engg., Excello Corp., Detroit, Mich.
Fairchild, E. L., asst. prof. of elec. engg., Wayne University, Detroit, Mich.
Gutsch, F. L., elec. engr., El Paso Electric Co., El Paso, Tex.
Hamann, C. E., mgr., application engg. section, General Electric Co., West Lynn, Mass.
Hehner, N. E., chief engr., Auto-Lite Battery Corp., Owosso, Mich.
Horn, R. T., engr., St. Joseph Light & Power Co., Maryville, Mo.
Howard, F. C., asst. supt., kramer power station, Nebraska Public Power System, Bellevue, Nebr.
Hull, R. S., elec. research engr., National Cash Register Co., Dayton, Ohio
Jordan, C. E., chief elec. engr., General Industries, Inc., Philadelphia, Pa.
Kaplan, R., elec. engr., Howell Electric Motors Co., Howell, Mich.
Kemp, H. L., assoc. elec. engr., Public Lighting Commission, Detroit, Mich.
Klumb, R. K., senior substation engr., Southern California Edison Co., Los Angeles, Calif.
Lane, G. L., elec. design engr., Washington Water Power Co., Spokane, Wash.
Lefler, C. C., design engr., Kuhlman Electric Co., Bay City, Mich.
Mangum, G. G., chief elec. engr., Headquarters Air Training Command, Scott AFB, Ill.
Mann, W. B., treasurer & elec. engr., The Wolfe & Mann Mfgr. Co., Baltimore, Md.
Martin, S. A., supt. of underground lines, Columbus & Southern Ohio Electric Co., Columbus, Ohio
May, J. C., asst. prof. of elec. engg., dunham lab., Yale University, New Haven, Conn.
Merriam, F. R., project engr., Redmond Co., Inc., Owosso, Mich.
Merrill, R. L., asst. supervisor, Battelle Memorial Institute, Columbus, Ohio
Mitchell, C. A., vice pres., Day & Zimmermann, Inc., Philadelphia, Pa.
Moriaty, J. D., elec. engr., Gulf Oil Corp., Port Arthur, Tex.
O'Brien, R. P., supervising engr., public utilities dept., California Public Utilities Commission, San Francisco, Calif.
Owen, T. B., research engr., Hughes Aircraft Co., Culver City, Calif.
Paige, A. E., assoc. prof., elec. engg. dept., University of Denver, Denver, Colo.
Palmer, L., engr., Puget Sound Power & Light Co., Seattle, Wash.
Parks, R. C., asst. sales mgr., Howell Electric Motors Co., Howell, Mich.
Peirce, H. B., vice pres., International General Electric Co., Inc., New York, N. Y.
Pollock, R. B., elec. engr., Southern California Edison Co., Los Angeles, Calif.
Powell, R. M., electronic engr., Naval Ordnance Laboratory, Silver Spring, Md.
Pringle, A. E., vice pres. & chief engr., Pringle Elec. Mfg. Co., Philadelphia, Pa.
Roadhouse, G. S., substation engr., Omaha Public Power District, Omaha, Nebr.
Rumohr, C. G., system relay engr., Public Service Co. of Colorado, Denver, Colo.
Smith, S. L., supt. of power, Philadelphia Transportation Co., Philadelphia, Pa.
Strobel, H. C., acting aerial lines engr., Potomac Electric Power Co., Washington, D. C.
Takle, K. J., electronic scientist, U.S.N. Electronics Laboratory, San Diego, Calif.
Tayler, W. L., engr., Commonwealth Edison Co., Chicago, Ill.
Thompson, R. P., asst. chief transformer engr., Line Material Co., Zanesville, Ohio
Vogel, G. E., elec. engr., Tennessee Valley Authority, Chattanooga, Tenn.
Warren, C. E., assoc. prof. of elec. engg., Ohio State University, Columbus, Ohio
Weimer, F. C., assoc. prof. of elec. engg., Ohio State University, Columbus, Ohio
Westbrook, W. L., div. supt., Georgia Power Co., Columbus, Ga.
Whitaker, G. R., div. supt., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Wilie, C. L., Jr., relay engr., Texas Power & Light Co., Dallas, Tex.
Witt, E. T., asst. elec. engr., Stone & Webster Engg. Corp., Boston, Mass.

75 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before June 25, 1951, or August 25, 1951, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Andrews, J. K., Collyer Insulated Wire Co., Pawtucket, R. I.
Andrus, O. E., A. O. Smith Corp., Milwaukee, Wis.
Basnett, R. T., Westinghouse Elec. Corp., New York, N. Y.
Berring, H., Weston Electrical Instrument Corp., Newark, N. J.
Bolton, D. J., British Electricity Authority, London, England
Bradley, J. F., Jr., General Elec. Co., St. Louis, Mo.
Brown, C. C., General Elec. Co., Los Angeles, Calif.
Brubaker, J. F., Westinghouse Elec. Corp., Sharon, Pa.
Chakrabartty, D. N., College of Engg. & Tech., P. O. Jadavpur College, Calcutta, India
Cooper, V. E., Cincinnati Gas & Elec. Co., Cincinnati, Ohio
Eiselein, J. E., RCA Victor, Camden, N. J.
Eppes, J. B., Jr., Rural Electrification Admin., Washington, D. C.
Evans, W. J., Ford Motor Co., Detroit, Mich.
Fitzgerald, G. W. N., Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
Flading, R. E., Johns-Manville Sales Corp., Cleveland, Ohio
Gustaveson, J. W., Gustaveson, Inc., Dodson, Mo.
Hand, E., Nashville Elec. Service, Nashville, Tenn.
Hill, D. M., Boonton Radio Corp., Boonton, N. J.
Hose, R. H., Henry Dreyfuss, New York, N. Y.
Jones, W. D., Wm. J. Moran Co., Alhambra, Calif.
Jordan, E. L., University of Kansas, Lawrence, Kans.
Juggins, C. E., General Motors Holdens, Melbourne, Australia
Kallas, E., Jack S. Steele Co., Philadelphia, Pa.
Karlson, A. T., Westinghouse Elec. Corp., Chicago, Ill.
Kegelman, W., Philadelphia Elec. Co., Philadelphia, Pa.
Leardini, T., Societa Termoelettrica Veneta, Venezia, Italy
Loucks, W. W., Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
MacNichol, G. F., Southern Bell Tel. Co., Miami, Fla.
Mancke, R. B., American District Telegraph Co., Inc., New York, N. Y.
McMeekin, S. C., South Carolina Elec. & Gas Co., Columbia, S. C.
Mejia L., F., Edificio Banco de la Republica 612, Medellin, Colombia, South America
Moosbrugger, F. J., Public Service Co. of No. Illinois, Northbrook, Ill.
Myers, E. C., 3612 Tennyson St., San Diego, Calif.
Neukomm, W. H., Southwestern Bell Tel. Co., Wichita, Kans.
Pai, M. H., Taiwan Power Co., Taiwan Trading Corp., Taipeh, Taiwan, China
Priest, E., Public Service Co. of New Hampshire, Keene, N. H.
Ratz, A. G., University of Toronto, Toronto, Ontario, Canada
Reinhard, C. K., N. Y. Telephone Co., White Plains, N. Y.
Robertson, D. G., RCA Victor Div., Camden, N. J.
Smith, D. H., Bell Tel. Labs., Inc., New York, N. Y.
Snell, H. R., Raytheon Mfg. Co., USNAMTC, Pt. Mugu, Calif.
Street, W. G., The British Aluminum Co. Ltd., London, England
Thomas, W. S., Detroit Edison Co., Detroit, Mich.
Whiting, C. R., N. Y. Telephone Co., New York, N. Y.
Worby, A. E., Demerara Bauxite Co. Ltd., Georgetown, British Guiana, South Africa

45 to grade of Member

OF CURRENT INTEREST

Englewood, N. J., Telephone Subscribers to Get Coast-to-Coast Dialing Equipment

The first coast-to-coast dial call by a telephone subscriber will be made this fall. Equipment required for the initial use of coast-to-coast dialing by customers will be installed in the Englewood, N. J., exchange of the New Jersey Bell Telephone Company starting in June, and should be in use by the end of the year.

The intricate switching apparatus, development of which climaxes years of research by the Bell Telephone Laboratories, will enable subscribers to span the continent through ten pulls of the dial instead of the customary seven now used in completing calls to shorter distances.

In the initial phase of cross-country dialing, 10,000 customers in the Englewood exchange area will be able to dial directly to any of 11,000,000 telephones in such cities as San Francisco, Chicago, Cleveland, Detroit, and Boston and many of their adjacent suburbs.

Telephone operators have been dialing calls across the country for several years. At the present time one out of every three long-distance calls is dialed directly by the operator, but Englewood will mark the first time that subscribers will be able to dial calls covering so wide an area.

Long-distance calls, which averaged 14 minutes to connect 30 years ago and which average two minutes today, may be completed in a matter of seconds under subscriber long-distance dialing.

A country-wide numbering plan, which includes parts of Canada, plays a key role in the nation-wide dialing system. In all, there are more than 80 numbering plan areas, each of which is assigned a special 3-digit code. For example, on a call from Englewood to San Francisco, the subscriber will first dial the latter's code of "3-1-8" and follow immediately with the number of the telephone being called. On a call to a subscriber with the number of GArfield 1-9950 in San Francisco, the calling party will dial the 10-digit combination of 318-GA1-9950.

The equipment installed in the Englewood central office stores up the digits dialed, and as soon as the tenth digit is recorded the call is automatically switched over telephone highways to the called telephone in San Francisco. (Calls to some party-line telephones may require 11 digits before the call can be completed.)

At the start of the Englewood dial trial, 13 codes will be in use covering areas served by 800 central offices. In addition to the codes for San Francisco, other areas and their codes within the dialing range of Englewood subscribers will be: Philadelphia, 2-1-5; Providence, 4-0-1; Pittsburgh, 4-1-2; Cleveland, 2-1-6; Detroit, 3-1-3; Chicago, 3-1-2; Milwaukee, 4-1-4; Oakland, 4-1-5; Sacramento, 9-1-6; Bos 6-1-7.

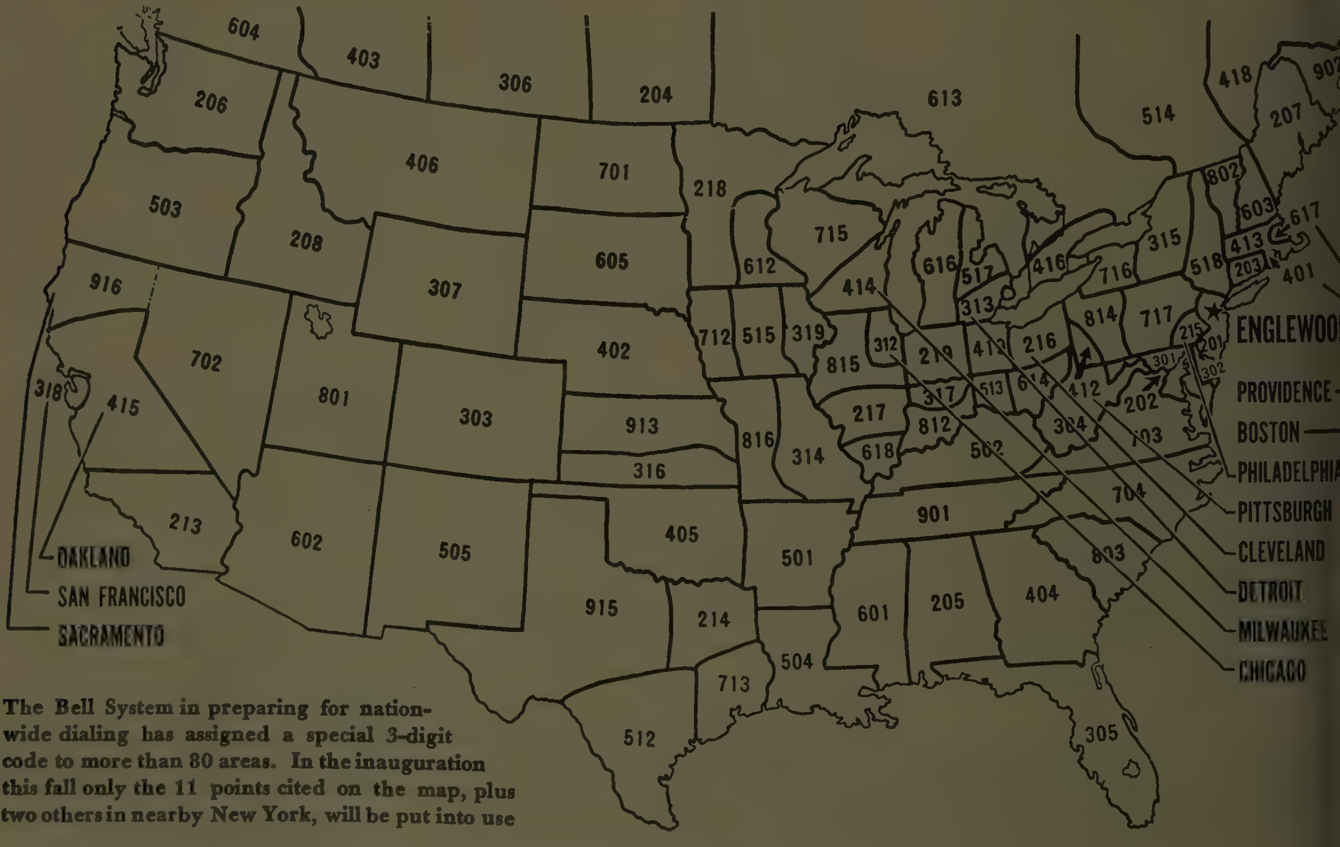
Additional areas in New York State will be within reach of Englewood s scribers through the use of two other cod

The trial customer long-distance dia is limited to Englewood, and it was emp sized that subscribers in the 13 areas will at this time be able to dial Englewood rectly even though they will be able to ceive direct dial calls from Englewood.

Keeping track of the charges on custom dialed long-distance calls also will be d automatically. Installations of Autom Message Accounting (AMA) equipment register each step of a call, including number of the calling telephone, the change and number of the called telepho date and time of day, and length of (An article entitled "Fundamentals of Automatic Telephone Message Account System" by John Meszar appeared in AI *Transactions*, volume 69, part I, 1950, pa 255–68).

The information is recorded on paper t which is later run through a decoding chine which assembles, translates, so summarizes, and prints the information i form that can be used in preparing tomers' bills. Busy and don't-answer c are automatically eliminated by the A machinery.

The first coast-to-coast dial call comes a time when the world is observing the 7 anniversary of the invention of the teleph by Alexander Graham Bell and 36 ye after the first coast-to-coast telephone in 1915.



The Bell System in preparing for nation-wide dialing has assigned a special 3-digit code to more than 80 areas. In the inauguration this fall only the 11 points cited on the map, plus two others in nearby New York, will be put into use

ew Luminous Flux Values Are Assigned Mercury-Vapor Lamps by the NBS

The National Bureau of Standards (NBS) nounces new luminous flux values for rcury-vapor lamps derived from the new otometric units which were formally ablished in this country by law in July, 50. The revaluation places mercury nps on a basis consistent with incandes- nt and fluorescent lamps. Standards of ndle power or luminous flux for the incan- scent and fluorescent lamps issued or librated by the NBS have been based on e new units since 1948 when such values re first introduced in the United States lowing international agreement. For in- ndescent lamps the changes in values thus ought about were relatively unimportant, ing less than one per cent for lamps in mmon use. No changes were necessary r fluorescent lamps because their develop- ent has been so recent that they have ways been calibrated in terms of the new its originally proposed in 1938. Changes the rated values for mercury lamps, how- er, are as large as nine per cent for one pe.

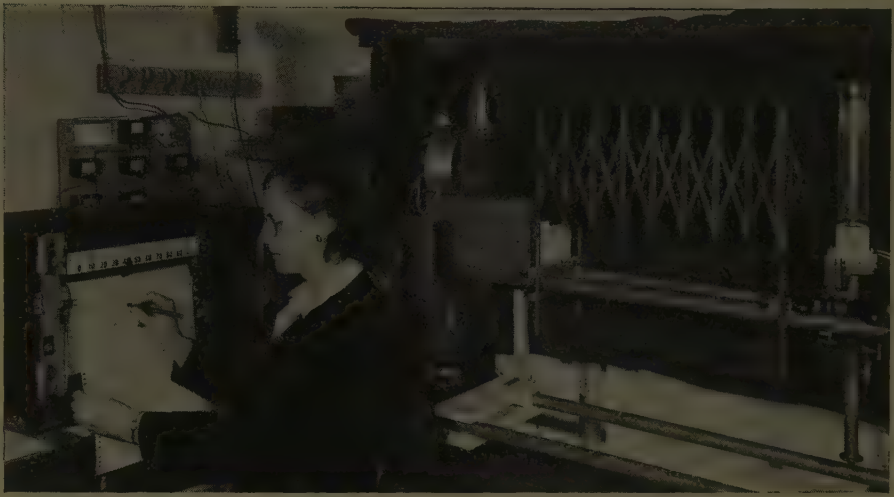
The chief advantages of the new system of otometric units are the establishment of e units on a reproducible physical basis d the international standardization effected the same time. In this system the unit of tensity of light is the candle, which is 60th the intensity of one square centimeter a perfect radiator (known as a "black dy") when operated at the temperature of eezing platinum. The unit of flux of light the lumen or the flux in a unit of solid angle om a source having an intensity of one ndle. The candle power and luminous x of lights whose colors are different from e primary standard are evaluated by eans of standard luminosity factors repre- nting the spectral sensitivity of the average e under specified conditions.

The mercury lamp standards involved in is revaluation are the 400-watt and the 0-watt sizes. They were originally evalu- ed in 1936 by direct visual comparison th the incandescent lamp standards in rce at that time. Such comparison, how- er, poses one of the most difficult of visual otometric problems because the spectral stributions of radiant flux in the two types light sources are of such radically different pes. The incandescent light gives a con- uous spectrum throughout the whole ible range. Light from the mercury arc, the other hand, is concentrated largely in few lines in the yellow, green, blue, and olet regions of the spectrum. Even ough calibrated filters are placed over the candescent lamps to give an approximate lor match, there still remain the usual dividual observer differences common to terochromatic photometry but accentu- ed in this case by possible large differences macular pigmentation among the ob- rvers. Although eight observers were ed in the 1936 measurements and the otometric conditions such as field size and minance (photometric brightness) were ose accepted as standard for such work, the al values were unavoidably subject to nsiderable uncertainty, as recognized at at time.

The development of an accurate physical photometer by the NBS has made possible the revaluation of the candle power and luminous flux of these mercury-vapor lamp standards with greatly increased certainty. While the idea of the physical photometer is not new, its development to the present state of perfection by the Bureau is largely responsible for the improved accuracy. There are two principal elements in this instrument: the thermopile detector with its amplifying and recording attachments, and the luminosity filter by means of which the radiant flux incident on the detector is weighted to give a response which is proportional to that of the average human eye.

Major improvements have been introduced into both of these elements since the equipment was first designed in 1941. The sensitive galvanometer and potentiometer originally used have been replaced by a photoelectric self-balancing potentiometer and amplifier; the output is used to operate a recorder. The use of a sectored disk driven by a synchronous motor gives equal periods of "light-off" and "light-on," and the recorder automatically provides a record of the readings and plots a graph to determine the response, without the necessity of balancing the potentiometers.

Manufacturers of and others interested in mercury-vapor lamps have been kept informed of the progress of this work. By mutual agreement, effective August 1, 1950, all calibrations of mercury-vapor lamps are on the new basis.



A physical photometer consisting of a luminosity filter and thermopile, with auxiliary apparatus, being used at the National Bureau of Standards to measure the luminous intensity of a mercury-vapor lamp. From left to right on the bar photometer are (1) a large brass black body in which the thermopile is mounted, (2) the luminosity filter, which accurately duplicates the spectral sensitivity of the human eye, and (3) a rotating disk, which gives equal periods of "light on" and "light off"

Electrical and Magnetic Magnitudes and Units to Have International Standards

Continuing progress is being made in the direction of international standardization of electrical and magnetic magnitudes and units under the auspices of Technical Committee Number 24 of the International Electrotechnical Commission (IEC). Existing differences of definitions in different countries are being eliminated gradually. This, it is anticipated, will be of benefit to electrical engineering throughout the world.

One of the over-all objectives of the committee is to formulate for general acceptance the meter-kilogram-second (MKS) system, sometimes called the Giorgi System. Use of the MKS system results in units of current, voltage, and resistance which are respectively the ampere, the volt, and the ohm. This makes it more suitable for engineering work than the centimeter-gram-second (CGS) system, which is in widespread use. It is recognized, however, that the CGS system has certain advantages for physicists. There is no thought of replacing one by the other, but simply of providing a second system that will be particularly helpful to engineers.

Prior to World War II, meetings of Technical Committee Number 24 were held on an average of about once every two years. Due to the war and later the death of the committee's chairman, Professor Kennelly of Harvard University, no meetings were held from 1938 until last summer when the committee met in Paris, France, on July 17 and 18.

Representatives who attended the meet-

Future Meetings of Other Societies

American Society for Testing Materials. Annual Meeting. June 18–22, 1951, Chalfonte-Haddon Hall, Atlantic City, N. J.

Compressed Air and Gas Institute. June 7–8, 1951, Seaview Country Club, Absecon, N. J.

Conference on Industrial Research. Second Annual Meeting. June 11–15, 1951, Department of Industrial Engineering, Columbia University, New York, N. Y.

Edison Electric Institute. 19th Annual Convention. June 5–7, 1951, Denver, Colo.

Hydraulic Institute. June 11–13, 1951, Seaview Country Club, Absecon, N. J.

Institute of Aeronautical Sciences. Annual Summer Meeting. June 27–28, 1951, Institute of Aeronautical Sciences, Western Headquarters Building, 7660 Beverly Boulevard, Los Angeles, Calif.

Institution of Electrical Engineers. Conference on Electrical Instrument Design. May 28–31, 1951, The Institution Building, London, England.

The American Society of Mechanical Engineers. Semiannual Meeting. June 11–15, 1951, Royal York Hotel, Toronto, Ontario, Canada.

ings from the United States were: Dr. C. C. Chambers, Acting General Manager, School of Electronics, University of Pennsylvania; J. W. McNair, American Standards Association; Professor R. Rüdenberg, Electrical Engineering, Harvard University; Professor H. M. Turner, Department of Electrical Engineering, Yale University; Dr. J. J. Smith, General Electric Company of Schenectady; and the late Professor E. Bennett, Consulting Engineer, University of Wisconsin.

Three matters that had been on the agenda of the 1938 meeting, held at Torquay, England, were carried over and placed on the agenda of the Paris meeting. One concerned the adoption of a name for the unit of force in the MKS System to correspond with the dyne in the CGS System. The Torquay meeting had favored the name "Newton" for this unit, subject to ratification by the various national committees. During the interval between meetings, the IEC Central Office had canvassed the committees and received favorable votes from 16 countries. No unfavorable votes were received.

In the light of these replies, the committee, at its meeting last summer, recorded that "Newton" was formally adopted as the name of the unit of force in the MKS System.

A second matter carried over from the Torquay meeting concerned the selection of an electrical unit for the MKS System, which previously had only units of length, mass, and time. After a long discussion at the Paris meeting, in the course of which the delegates expressed the views of their respective countries, an Editing Committee was appointed to prepare a draft that would be acceptable to all.

The resolution suggested by this Editing Committee, which was unanimously approved, stated:

"Technical Committee Number 24 considers it convenient to base the Giorgi system for electrical quantities on four principal units, and recommends that, for the purpose of developing the definitions of the units, the fourth principal unit should preferably be the ampere, as defined by the General Conference on Weights and Measures."

Rationalization of electrical and magnetic units had been on the agenda of the committee's previous meeting at Torquay in 1938, but consideration of the question was deferred at that time. In the interval between meetings, proposals were circulated regarding the adoption by the IEC of a well-defined rationalization process so as to avoid the possibility of different rationalization processes being adopted in the various countries. Ten countries commented on these proposals, nine expressing themselves in favor of rationalization and one expressing no definite opinion.

The form of rationalization adopted at the Paris meeting results in the adoption of the following formulae:

$$\mu_v = 4\pi \times 10^{-7}$$

for the measurement of the magnetic permeability of free space; and

$$\epsilon_v = \frac{1}{\mu_v C^2}$$

for the measurement of the dielectric constant of a vacuum, C being the velocity of light in free space.

While a decision was reached that rationalization should be adopted, it was decided that the rationalization process should be re-examined by the national committees after the question has again been clearly put to them. An Experts Committee was set up to study the rationalization process with a view to placing the matter before national committees in accordance with the preceding decision.

In addition to study of the matter of rationalization, the Experts Committee was asked by the Technical Committee to consider two other questions: 1. definition of the quantity "magnetization," and 2. the sign of reactive power. These questions will be brought up for discussion at the next meeting of Technical Committee Number 24.

As a result of a meeting July 18, the Experts Committee made the following proposal:

"That the word 'magnetization' in English and the word 'aimantation' in French should be adopted as the name for the axial vector **J**, which is introduced in the form shown below into the expression giving the magnetic flux density **B** as a function of the field strength **H** and of the magnetic permeability μ_0 of free space:

$$\mathbf{B} = \mu_0(\mathbf{H} + \mathbf{J})$$

the term 'magnetic polarization' being reserved to the axial vector **M** in the equation:

$$\mathbf{B} = \mu_0\mathbf{H} + \mathbf{M}$$"

In 1935 the sign of reactive power was established at the suggestion of the United States delegation. Since then a large cross section of the power industry in this country has not found it possible to follow this recommendation because of certain practical points of view. There are several reasons for this which have to do with the flow of active and reactive power. Part of the difficulty is due to the fact that at any given point we may regard energy as being delivered or received. An indication of some of the thinking will be found in the two AIEE reports: *Electrical Engineering*, volume 65, 1946, pages 612–16; and *Electrical Engineering*, volume 67, 19
pages 49–52.

These considerations may have beco
apparent also in other countries. Therefo
it was recommended that this item be co
sidered at a future meeting of Adviso
Committee Number 24 following that
Paris in 1950. This will give represen
tives on the committee time to obt
the views of their countries on this subje

Army Advises Specialists on How to Ask for Appropriate Branch

Persons about to enter military serv
who have certain communications, el
tronics, or photographic experience are
ing offered advice by the United Sta
Army Signal Corps on how to ask for that
some other appropriate branch.

The Army feels it is mutually desirable
the individual to continue, so far as possib
his civilian specialty while in service.
the same time, it was pointed out, commu
cations specialists are critically needed.

To facilitate the assignment of technica
trained inductees where their skills can
fully utilized, numerous organizations, lab
unions, and business firms are being invit
to provide their personnel with "stateme
of experience" which can be brought to
ception centers by individuals called in
service. Interviewers will ask for su
statements. The form for the stateme
along with other pertinent details, can
obtained from the Signal Corps upon reque

The Army believes that the individual,
civilian connection, and the Service w
benefit by optimum use of specialists. In
viduals will remain free to waive special
identification and assignment in favor of co
bat arms training and assignment to lead
ship or Officer Candidate School training.

The Army cautioned that only certa
types of skills are critically needed, and th
not every inductee bearing a statement of
perience or other credentials can be reas
ably assured of a Signal Corps assignme
The Army currently needs high-speed ra
operators, medical equipment repairm
motion picture photographers, cable splice
electronics equipment repairmen, telety
writer repairmen, tabulating equipment
pairmen, manual and dial telephone cent
office maintenance men, field and fixed s
tion radio repairmen, radar mechanics a
repairmen, electric instrument and spec
device repairmen, repeatermen, and sin
side-band radio repairmen. Where civili
skills do not exactly fit military job titles,
Army recommends that the most ap
cable be used on statements of experienc

Inductees are advised to show their sta
ments, if requested, at induction statio
but not to surrender them there. The sta
ments of experience should be used in int
views at reception centers. At no ti
should personal papers be surrendered.

First Convention of UPADI Held in Havana April 19–22

The first convention of the Pan Ameri
Union of Engineering Associations (UPA
was held from April 19–22, 1951, in Hava
Cuba. Representatives of many of

gineering societies of the Western Hemi- here were present. The purpose of PADI is to achieve a closer understanding the engineering societies of the Western misphere and its objectives include: ndardization of technical criteria; contri- tions to the study and solution of common oblems; uniform and general standards technology and specifications; promulga- n of a Code of Professional Ethics; the erchange of technical and professional vice and assistance; and creation of firm hesion among all engineers in the Americas.

The Committee on Publications and Public formation made the following recom- endations: the creation of a permanent PADI Secretariat and the publication of UPADI Bulletin, to be printed in three guages; English, Portuguese, and Spanish.

Delegates to the first convention of the Pan American Union of Engineering Associations included representatives of engineering societies from nearly all the Americas. AIEE President LeClair is shown third from the right

C.I. Will Hold 12th Session in Stockholm, Sweden

The 12th Session of the International Com- ssion on Illumination (I.C.I.) will be held Stockholm, Sweden, from June 26 to July 1951. At this session 25 technical com- ttee reports and 42 papers will be pre- nted. Contributing countries will include: nited States, Great Britain, the Nether- nds, Sweden, and France.

Copies of the preprints may be obtained at cents per copy from Mr. L. E. Barbrow, cretary of the United States National Com- ttee of the I.C.I., National Bureau of andards, Washington 25, D.C.

exas Eastern Plans New Micro-wave Communication System

Plans for one of the most extensive and odern microwave systems in the United ates have been announced by Texas stern Transmission Corporation. De- ned to expedite the flow of natural gas om Louisiana and Texas fields to the highly dustrial East, the system will employ pulse- ne modulation (PTM) multiplex equip- ent developed and manufactured by Fed- al Telephone and Radio Corporation, ifton, N. J., associate of International lephone and Telegraph Corporation.

The route of the system will be from the mpany headquarters at Shreveport, La., Kosciusko, Miss., then along the route of e 30-inch pipe line now under construction Connellsville, Pa., and from there to the stern terminal at Linden, N. J.—a dis- nce of approximately 1,400 miles. This tem will provide various communication cilities between Shreveport, the pipe-line mpressor stations, and divisional offices ong this route.

Texas Eastern's PTM microwave system ll operate at 2,000 megacycles to provide gh-quality communication facilities.

Because of its adaptability to both short- d long-hop operation, this system is ecially well suited for pipe-line communi- tions. Initially, it will be equipped for eration on eight voice channels, with pro- ion for very-high-frequency mobile radio nnection, dispatching, administrative, tele- etering, and supervisory services. Should ditional facilities be necessary, the system may be readily expanded to provide a total of 23 communications channels.

GE Electric Steering Equipment To Be Used on Navy Destroyer

New steering equipment, providing both automatic and manual control, has been developed by the General Electric Aeronautic and Ordnance Systems Divisions for the United States Navy.

Designed to provide completely automatic steering in addition to portable hand electric steering, the new unit will be installed on a vessel currently under construction.

An important feature of the new control is an instantaneous override which permits the helmsman to take control away from the automatic pilot to initiate evasive action or avoid collision. The new ship also has a remodeled pilot-house console that features red internal illumination designed to eliminate glare from the dials. In addition magnetic, rather than electronic, amplifiers are used throughout the unit.

The portable steering equipment is a remote control box that enables the vessel to be steered from various points about the ship. This secondary control station is intended primarily for use in case of battle damage to the pilot house, whereupon the ship would be controlled from selected steering stations provided for such an emergency. The unit is mobile and is supported from shoulder straps or a fixed bracket.

The remote steering unit shown here being operated by a Navy officer can be used to steer a ship from widely separated strategic spots aboard ship in case of battle damage to the bridge. The remote control unit, along with an automatic steering unit, has been developed by General Electric especially for the Navy

Output of Rebuilt Italian Power Plants Twice Prewar Level

The Larderello natural steam power plants in northern Italy, almost totally destroyed by the Germans in World War II, have been rebuilt and expanded to almost twice their prewar kilowatt output. These plants generate electricity from torrents of natural steam which come from cracks in the earth at speeds as high as 1,300 feet per second.

Before the war, the power and chemical plants of Larderello produced a yearly average of 980,000,000 kilowatt hours of electricity and many thousands of tons of raw boric acid and other chemical by-products of the chemically rich steam. Destruction of these plants was such that after the liberation production of both electric power and chemical products was impossible.

During the four years following the liberation, about 18 turbogenerators were placed in operation with a total output of approximately 150,000 kw. Today, with a new power plant, there are 21 turbogenerator sets with a total output of 254,500 kw, nearly double the 135,000-kw output of the 16 prewar sets. Erection of Larderello's newest power plant was started in April 1947. Its plant and machines are of Italian design and manufacture.

New 4-Foot Rolatape Measuring Wheel Announced

A measuring wheel which is exactly four feet in circumference and registers distances up to 100,000 feet, then repeats the cycle, has been announced by Rolatape, Inc., Santa

The new measuring wheel made by Rolatape, Inc., Santa Monica, Calif., is easily operated by one man. It measures and records as it is wheeled over a course. The wheel makes possible safer measurement in traffic and in congested areas

Monica, Calif. It measures and records as it is wheeled over the course. The wheel does not sway in operation, but tends to stabilize its course and follow a straight line.

The model *400* Rolatape has been field-tested and is being used in electric light and power applications such as pole spacing, spotting faults, map checking, rechecking of questionable invoices, and general estimating work involving utility extensions, conduits, piping underground lines, fencing, wire requirements, and so forth. It measures around corners and over contours with equal facility and accuracy.

It weighs only five pounds and is operated easily and efficiently by one man. The counter is in plain view at all times. The handle folds so that the wheel can be carried and stored in car or truck compartment. A stand holds the wheel upright while the operator is logging data, without losing count of distance. The wheel also can be operated by the driver of a car as he drives slowly over the course to be measured. The Rolatape is calibrated accurately and is constructed to withstand years of field usage.

Concentrated Liquid Ozone Now Can Be Manufactured Safely

By successfully taming concentrated liquid ozone, scientists have developed a fuel that someday may send rockets to the moon. Recent advances at Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill., prove that concentrated liquid ozone, a dark blue substance, can be handled safely.

More than just a rocket fuel, ozone has other valuable military and commercial applications. It can be decomposed directly to oxygen for submarine patrols and high-altitude flying and is an ideal agent for water purification, air purification, and bleaching.

By demonstrating that ozone may be safely manufactured, scientists at the Foundation have opened the door for possible tonnage production.

During World War II, German scientists worked on an ozone-propelled rocket designed to bombard New York City from launching platforms over 4,000 miles away. Luckily, the Germans were unable to discover the secret of handling liquid ozone without spontaneous detonation. Otherwise, residents of that area might have had front-row seats for a preview of guided missile warfare.

By replacing oxygen tanks with containers of liquid ozone, both planes and submarines would gain additional space with no sacrifice in oxygen volume.

Used for water purification, ozone is a powerful chemical that literally "burns up" impurities without leaving an unpleasant taste. Large cities, such as Philadelphia, Pa., and Paris, France, and smaller communities, including Whiting and Hobart, Ind., have used ozone water purification systems for years.

An excellent deodorizing agent, dilute solutions of ozone in ventilating systems will overpower the smell of fish oils and rancid fats. As a bleaching agent, ozone is superior to chlorine, hydrogen peroxide, and other liquid bleaches as it leaves no detrimental residue which ultimately decreases the strength of the bleached material. Already in use in Europe as a bleaching agent, ozone works on paper pulp, blood, starches, and oils. It also has been used for oxidizing oils in the manufacture of linoleum.

Ozone can readily be made by bombarding oxygen with high-speed electrons. T technique duplicates nature's own meth and explains why ozone can be smelled in air immediately after a summer thund shower.

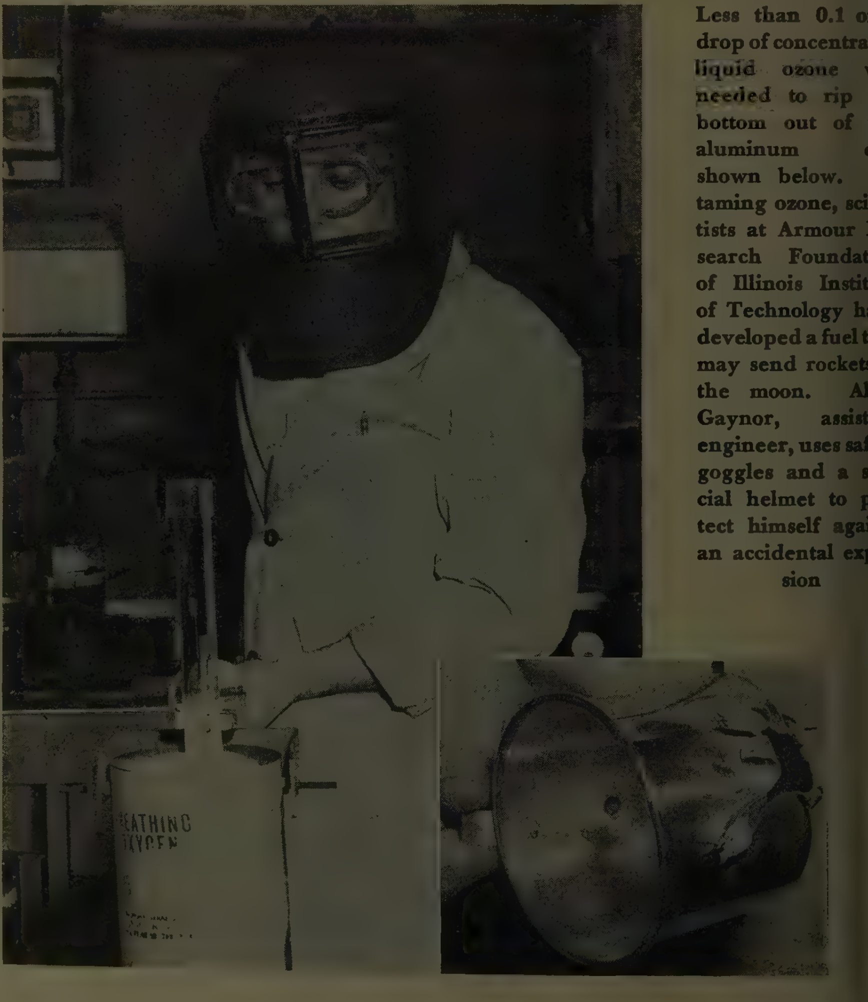
Originally, ozone research was sponso by the Foundation, but since 1945 all w has been under the sponsorship of the Reduction Company, Inc., manufactu of purified gases such as oxygen, nitrog helium, and neon.

ASA Receives Certificate of Co-operation from ECA

A Certificate of Co-operation was p sented to the American Standards Ass ation (ASA) today by the Economic operation Administration (ECA) at spring meeting of ASA's Board of Direct This award was presented to Thomas Jolly, President of ASA, by the Honora Walter T. Shirley, Commissioner of Co merce of the City of New York, on behal William C. Foster, administrator of ECA

The certificate was given in recognition ASA's assistance and co-operation in help technical missions from overseas coming this country to study United States standa ization and simplification practices and te niques. Through its broad connections the national clearing house for standar ASA has arranged plant visits and con ences for these missions so that they co get a first-hand working knowledge of Ame can standardization methods.

ASA has received delegations represent



Less than 0.1 of drop of concentrat liquid ozone w needed to rip t bottom out of t aluminum c shown below. taming ozone, sci tists at Armour R search Foundat of Illinois Instit of Technology ha developed a fuel t may send rockets the moon. Al Gaynor, assist engineer, uses saf goggles and a s cial helmet to p tect himself agai an accidental exp sion

anagement, labor, and government from e United Kingdom, Sweden, Greece, and e Netherlands, and will soon meet with e French. These groups have shown rticular interest in American simplification chniques and in the use of standards as a eans of increasing over-all production.

ngineering Manpower Commission Issues First Report

The Engineering Manpower Commission Engineers Joint Council has announced at its first report on "Utilizing Engineering anpower" is now available. This report ings together procedures to be followed in questing necessary occupational deferments d delays for both reservists and draftees. ie report also includes a brief statement on e problems of both government and indus- y in selecting and utilizing personnel.

Because of the extreme critical shortage of gineers, coupled with an increasing de- and for engineers for defense purposes, it believed that the report will be of much lue to engineers or their employers.

Copies of the bulletin may be obtained om Engineering Manpower Commission, West 39 Street, New York 18, N. Y., at charge of 25 cents.

5th Annual Meeting Held by Engineering Institute of Canada

The members of the Engineering Institute Canada held their 65th annual meeting the Mount Royal Hotel, Montreal, ntario, Canada, from May 9–11, 1951. ie Institute has 33 branches which are cated in all provinces and the membership over 15,000.

Some of the technical subjects that were scussed included: Canadian Military rcraft; Research in Gas Dynamics; ectrothermal De-icing of Aircraft; Air nitation; St. Lawrence Waterway; and hers.

Ira P. Macnab of Halifax, Nova Scotia, as elected President of the Institute for is year.

ew Nonexplosive Device Used to Break Down Coal

The development of a nonexplosive device breaking down coal has been announced the Du Pont Company. It is "Cheme- ol," a chemicomechanical device which eaks coal from a mine face by the force of mpressed gas generated by chemical reac- n in the device and released mechanically.

The new device consists of a steel tube closing a chemical unit. The tube is sed at one end by a plug having electric nnections, and at the other end by a rup- able disc held in place by a perforated ad. After the tube is placed in a hole illed in the coal face, the chemical reaction activated by an electric current controlled thin narrow limits. Heat is produced ich, after a few seconds, destroys the rter wire, thus breaking the electric cir- t. The chemical reaction thereafter continues to liberate gas which builds up to a predetermined pressure, at which point the disc ruptures. The gases rush out through the ports in the head and break down the coal. The tube, refilled in the mine with another chemical unit and disc, is used repeatedly.

Chemechol produces no flame. It cannot be activated by small electric currents, such as stray currents, nor by high currents, such as mine lighting or haulage circuits. Chemechol units cannot be detonated by blasting caps or high-strength dynamite.

At the present time this new product is in the transition stage from the laboratory to extensive field testing. Field tests to date have been successful. The product has produced a maximum of coarse coal with maximum safety and with a high degree of over-all efficiency.

New Process Developed for Soldering Glass to Metal

Engineers now can solder glass to metal in a process which makes a bond stronger than the glass itself. The method, which also can be used to solder metal to ceramics and carbon, was originated by scientists of the General Electric Research Laboratory. It is being tested now for industrial applications.

The glass and metal areas to be soldered are painted with a thin layer of titanium hydride, and solder is placed upon both painted areas. The parts are placed together and then heated under a vacuum.

When the temperature reaches about 900 degrees Fahrenheit, the titanium hydride decomposes. This causes the solder, which already has become molten, to adhere to the titanium-painted areas of both glass and metal. A strong, tight bond is formed upon cooling.

By using soft metal solders, it is possible to subject this glass-to-metal seal to rapid temperature changes without danger of cracking, despite the wide difference in temperature expansions between glass and metal. This is possible because the differences in movement are absorbed by the solder.

The new technique is now in use in aircraft ignition systems, and laboratory investigations have suggested possible applications in the manufacture of transformers, capacitors, and electric motors.

University of Denver Offers Research Fellowships to Engineers

Research fellowships in electrical engineering will be awarded by the Institute of Industrial Research, University of Denver. The stipend is $3,300 for 21 months starting September 1, 1951. The recipients will work approximately 25 hours per week in the Institute of Industrial Research on industrial research projects leading to the fulfillment of the thesis requirement, while engaged in graduate study leading to the master of science degree in electrical engineering. Interested applicants should send transcript of college record, personal data, and names of three persons acquainted with their work to the Director, Institute of Industrial Research, University of Denver, Denver 10, Colo.

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ALTERNATING-CURRENT CIRCUITS. By R. M. Kerchner and G. F. Corcoran. Third edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1951. 598 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, $5.50. Intended for students majoring in power or communication work, this book covers the theory and practice of the subject with particular emphasis on fundamentals. Changes in this third edition include: material on the loss and phase characteristics of elementary 4-terminal networks; material pertaining to the Q of electric circuits is revised, and the nodal method of circuit analysis is used; an additional method of wave analysis is introduced; a method of designing tuned coupled circuits is included; and the 3-origin vector diagram of a polyphase circuit is added. The end-of-chapter problems are revised and new problems included.

APPLIED NUCLEAR PHYSICS. By E. C. Pollard and W. L. Davidson. Second edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1951. 352 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, $5.00. The book covers practically all phases of nuclear science including the basic facts of nuclear particles and radiations and methods of accelerating them, transmutation, natural and artificial radioactivity, isotopy, and nuclear fission. In addition to incorporating material covering the progress in the field since the first edition in 1942, a new chapter on nuclear chain reactions has been added. Special sections devoted to pile theory, neutron diffraction, cross sections, and cosmic rays are also new. Detailed instructions on laboratory experiments are now included, and the tables of nuclear data are brought up to date.

CHROMIUM PLATING. By E. S. Richards. Third edition revised and enlarged. Charles Griffin and Company, Ltd., London, W.C. 2, England, 1950. 154 pages, illustrations, diagrams, tables, $8^{1}/_{4}$ by $5^{1}/_{2}$ inches, fabrikoid, 17s. Intended for use by those acquainted with the process of chromium plating, this book deals with the practical production of the deposit and the best methods of ensuring regular outputs of the highest class. Chemical and theoretical considerations are not given a great deal of space, since the emphasis is on the practical side of plating.

CRITICAL REQUIREMENTS FOR RESEARCH PERSONNEL, March 1949, 66 pages. DEVELOPMENT OF A TEST FOR SELECTING RESEARCH PERSONNEL, January 1950, 33 pages. PROCEDURES FOR EVALUATING RESEARCH PERSONNEL WITH A PERFORMANCE RECORD OF CRITICAL INCIDENTS, Jun 1950, 42 pages. American Institute for Research, Pittsburgh, Pa. Diagrams, charts, tables, 11 by $8^{1}/_{2}$ inches, paper. These three reports describe a part of a long-range program concerned with research in the effective utilization of scientific personnel. The first is devoted to a study of observed behaviors of personnel in research laboratories and provides a list of critical requirements for research personnel. The second is concerned with the development of a test for selecting research personnel; and the third, with procedures for evaluating research personnel on the basis of a performance record.

CRYSTALS AND THE POLARIZING MICROSCOPE. By N. H. Hartshorne and A. Stuart. Second edition. Longmans, Green and Company, New York, N. Y.; Edward Arnold and Company, London, England, 1950. 473 pages, illustrations, diagrams, charts, tables, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, linen, $9.50. This text on the structure and identification of crystals has been revised to include not only the simpler aspects of the polarising microscope but also more difficult problems and techniques. New chapters include an expansion of the former section on the preparation and mounting of materials and a consideration of liquid crystals. There is expanded treatment of index variation methods, the use of the universal stage, applications of the polarising microscope, and the relationships between symmetry and internal structure.

ELECTRICAL ENGINEERING DESIGN MANUAL. By S. P. Smith and M. G. Say. Second edition revised.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

Chapman and Hall, 37 Essex Street, London, W. C. 2, England, 1950. 259 pages, diagrams, charts, tables, $7\frac{1}{2}$ by 5 inches, linen, 16s. This book provides an introduction to the physical principles underlying electrical engineering design and contains calculations and graphical techniques appropriate to the drawing board. Part I covers electric machines, magnetic circuits, magnet coils, armature windings, synchronous machines, transformers, d-c machines, induction motors and starters, and field regulators. Part II is devoted to speed-time curves and energy consumption, field plotting, harmonic analysis, and transmission-line diagrams.

ELECTRONIC FUNDAMENTALS AND APPLICATIONS. By J. D. Ryder. Prentice-Hall, New York, N. Y., 1950. 806 pages, illustrations, diagrams, charts, tables, $8\frac{3}{4}$ by $5\frac{3}{4}$ inches, cloth, $9.00 (text edition, $6.75). This book covers the physical principles underlying electron tubes, the characteristics of the tubes themselves, and the electric circuits in which they are used. It is based on the material included in the author's "Electronic Engineering Principles" with major additions of electronic circuit material. New material on circuit applications includes nonlinear operation, amplitude, and frequency modulation and detection. The generation of nonsinusoidal waves is now treated, and the material on amplifiers expanded. A knowledge of simple a-c circuit analysis and the calculus and simple differential equations is assumed.

ELECTRONICS. By P. Parker. Longmans, Green and Company, New York, N. Y.; Edward Arnold and Company, London, England, 1950. 1,050 pages, illustrations, diagrams, charts, tables, 9 by $5\frac{1}{2}$ inches, cloth, $10.00. Intended to provide a background for the circuit specialist and a starting point for the tube specialist, this comprehensive work covers a wide range of electronic devices. Attention is paid mainly to the physical action of the respective types, but basic circuit work is also covered. Brief discussions are appended on the kinetic theory of gases, the focal lengths of thin electron lenses, the theory of the magnetron, and other special theories and attributes.

ENGINEERING MECHANICS. By S. Timoshenko and D. H. Young. Third edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 517 pages, diagrams, charts, tables, $9\frac{1}{4}$ by 6 inches, cloth, $5.50. This text on mechanics aims to acquaint the student with as many general methods of attack as possible, and to illustrate the application of these methods to practical engineering problems. In this third edition, the chief aim has been an improvement in the lists of unsolved problems. These problems serve the twofold purpose of presenting new material not included in the text proper and of providing an example for the student in the logical methods of approach to the solution of engineering problems.

ENGINEERING PROFESSION. By T. J. Hoover and J. C. L. Fish. Second edition. Stanford University Press, Stanford, Calif.; Geoffrey Cumberlege, Oxford University Press, London, England, 1950. 486 pages, diagrams, charts, tables, maps, $9\frac{1}{4}$ by $6\frac{1}{4}$ inches, fabrikoid, $7.50. ENGINEERING METHOD. By J. C. L. Fish. Stanford University Press, Stanford, Calif., 1950. 186 pages, diagrams, charts, tables, $9\frac{1}{4}$ by 6 inches, linen, $3.00. Serving both as a vocational guide and an analysis of the profession, this book describes the qualifications and duties of the professional engineer and his habit of mind. Following the discussion of who is an engineer, what is engineering, and the general scope of engineering, the next five chapters discuss specific types of engineering. The method of engineering is considered next, and then three chapters deal with vocational guidance, education, and the contribution of engineers to mankind. Chapters 9, 10, and 11 have been organized in a separate volume entitled "The Engineering Method."

FUELS AND COMBUSTION HANDBOOK. Edited by A. J. Johnson and G. H. Auth. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 915 pages, diagrams, charts, maps, tables, $9\frac{1}{4}$ by 6 inches, cloth, $12.50. This comprehensive reference work is devoted to the properties, uses, and combustion of solid, liquid, and gaseous fuels. The basic types of combustion of these fuels and the operation and use of combustion equipment are dealt with. Comparative tables showing the characteristics of optional equipment are given. The use of alignment charts, tables, and graphs provides quick solutions to problems in the selection and use of fuels. A wide range of topics is covered including synthetic fuels, smoke prevention, fuel handling and storing, chimney design, the heat pump, and miscellaneous sources of heat and power.

GRUNDLAGEN DER HÖCHSTFREQUENZTECHNIK (Technische Physik in Einzeldarstellungen, Number 7). By F. W. Gundlach, edited by W. Meissner. Springer-Verlag, Berlin, Göttingen, Heidelberg, Germany, 1950. 499 pages, diagrams, charts, tables, $9\frac{1}{2}$ by $6\frac{1}{2}$ inches, paper, 48 D.M. This book discusses and derives from basic physical principles the theoretical fundamentals of high-frequency technology. Such topics as electron flow, skin effect and dielectric loss, elementary waves and double conductors, waves and tubular conductors, spherical waves, and the 4-pole theory are treated. A basic knowledge of college mathematics is assumed. Advanced mathematics are introduced where needed, and the lesser known functions are represented graphically.

INTRODUCTION TO INDUSTRIAL ELECTRONICS (Prentice-Hall Electrical Engineering Series). By R. R. Benedict. Prentice-Hall, Inc., New York, N. Y., 1951. 436 pages, illustrations, diagrams, charts, tables, $8\frac{1}{2}$ by $5\frac{3}{4}$ inches, cloth, $6.35. Providing an introductory survey of the field, this book covers the subject from descriptions of the basic tubes and their behavior through a treatment of elementary circuits and typical applications. Emphasis is placed on gaseous tubes, phototubes, and cathode-ray oscilloscopes. Only brief treatment is given to amplifiers, oscillators, detectors, and modulators. A knowledge of elementary calculus, d-c circuits and apparatus, and a-c circuits is assumed. Problems and references follow each chapter.

INTRODUCTION TO SERVOMECHANISMS. By A. Porter. John Wiley and Sons, New York, N. Y.; Methuen and Company, Ltd., London, England, 1950. 154 pages, diagrams, charts, tables, $6\frac{3}{4}$ by $4\frac{1}{4}$ inches, linen, $1.75. Intended for the physicist and engineer who are interested in the subject, this book defines the term 'servomechanism' and indicates in terms of elementary examples the theoretical foundations of the subject. Particular emphasis is placed on the basic problems of servo design, namely, those of ensuring adequate damping and small dynamic lags. Illustrative diagrams are used extensively as a graphic supplement to the mathematical analysis.

(Der) KREISEL, SEINE THEORIE UND SEINE ANWENDUNGEN. Bd. 2, Die Anwendungen des Kreisels. By R. Grammel. Second revised edition. Springer-Verlag, Berlin, Göttingen, Heidelberg, Germany, 1950. 268 pages, diagrams, charts, tables, $9\frac{1}{2}$ by $6\frac{1}{2}$ inches, paper, 30 DM; linen, 33 DM. Volume II of a 2-volume set, this book, in three parts, considers the applications of the gyroscope. The first part describes gyroscopic effects in wheel sets of all kinds (including motor vehicles, ships, and airplanes). The second part is devoted to gyroscopic equipment used for navigation and control. The third part treats applications involving stabilizing problems. Many schematic sketches and cross sections of various types of gyroscopes are included.

SEMI-CONDUCTORS. By D. A. Wright. John Wiley and Sons, New York, N. Y.; Methuen and Company, London, England, 1950. 130 pages, diagrams, charts, tables, $6\frac{3}{4}$ by 4 inches, linen, $1.75. This elementary account of the properties of semiconductors places special emphasis on the theory of electron flow within them and across the boundary between them and either a metal or a vacuum.

TELEVISON AND FM ANTENNA GUIDE. By E. M. Noll and M. Mandl. Macmillan Company, New York, N. Y., 1951. 311 pages, illustrations, diagrams, charts, maps, tables, $9\frac{1}{2}$ by $6\frac{1}{4}$ inches, linen, $5.50. This book is both an antenna textbook and a practical guide to the many antenna problems encountered by television technicians. In addition to a thorough discussion on antenna installation and techniques, the reasons and logic underlying specific steps are detailed.

PAMPHLETS ● ● ● ●

The following recently issued pamphlets may be
interest to readers of "Electrical Engineering."
inquiries should be addressed to the issuers.

Tinplate Handbook. The steelmaking a
tinning processes used in the manufactu
of both hot-dipped and electrolytic tinpla
are summarized and the factors which dete
mine the suitability of the various types
tinplate for any particular application a
discussed. The major uses of the princip
grades of tinplate are indicated and metho
of testing mechanical properties, coati
thicknesses, and lacquer adhesion a
briefly described. The trade terms used
the British and American tinplate industri
are defined and methods of grading a
classifying the finished tinplates are reviewe
This publication is available free of char
from: Tin Research Institute, Inc., 4
West Sixth Avenue, Columbus 1, Ohio.

American Standard for Electrical Indica
ing Instruments. Users of portable a
laboratory indicating instruments now c
check them more easily for performance
be expected, and can determine from t
listed characteristics and limits the accura
class for any particular requirement. D
tailed charts, tabulated for easy referen
cover 33 types of panel, switchboard, a
portable equipment. This new edition
the standard covers a-c and d-c instruments
ammeters, voltmeters, single-phase and po
phase wattmeters, power factor mete
varmeters, and frequency meters. T
standard was developed by a committ
representing manufacturers, public utiliti
testing laboratories, and government d
partments under the procedures of t
American Standards Association. Copies
Standard *C39.1-1951* may be obtained fro
the American Standards Association,
East 45 Street, New York, N. Y., at $1.
per copy.

Standard on Class A Ovens and Furnac
Fire and explosion safeguards for industri
ovens are presented by the National Fi
Protection Association. These standar
apply to ovens where explosive vapors m
be produced from painted materials bei
dried or baked, impregnated materials, a
also where there is an explosion hazard fr
the fuel used. The standards stress t
importance of adequate ventilation to p
vent the development of explosive atm
pheres and specify control equipment
assure proper ventilation. All types
heating equipment are covered, includi
oil, fuel gases of various types, and el
tricity. This 72-page pamphlet is availa
for 75 cents from the National Fire Asso
tion, 60 Batterymarch Street, Boston
Mass.

Oxy-Acetylene Flames and Metalworki
This 16-page booklet traces the history of
oxy-acetylene flame and explains how
dustry is using it today in cutting, weldi
and heating operations. A copy of t
booklet may be obtained without cha
from the Linde Air Products Company,
East 42 Street, New York 17, N. Y.

by itself is a safety measure

* an original development of American Steel & Wire Company

AMERICAN STEEL & WIRE COMPANY
USS
AMERICAN ELECTRICAL WIRE AND CABLE
UNITED STATES STEEL

● There's an easy way to prove the effectiveness of PS Shielding. Just drive a spike through the PS conducting rubber tape into the copper conductor *without touching the ground wires*. Your breakers will trip every time, proving that PS Shielding *alone* is an outstanding safety measure for the protection of all who handle your cable.

Naturally, the PS grounded tapes can't carry heavy currents, so they're usually used in combination with ground wires. But PS Shielding will easily handle the circumferential current of the cable. In other words, it will do everything that metallic shielding will do *with these added advantages:*

Prevents Corona Discharge —PS Shielding is so flexible that it never pulls away from the insulation. This is in sharp contrast to metallic shielding which often separates from the insulation when the cable is bent. Each of the resulting gaps is a serious danger point since it may cause spark discharge plus the inevitable corona and ozone formation.

Easy to Splice —PS Shielding is available in rolls. For most splices you can apply your shielding to the splice just like ordinary insulating tape.

Reduces Bulk —PS Shielding has less bulk and weight than metallic shielding. Consequently, the cables are lighter, smaller, and in general—easier to handle.

Increases Cable Life —PS Shielding is so smooth and pliable that it won't chafe the insulation or jacket. There are no fine wires to break when the cable undergoes hard usage.

For the full story on PS Shielded Cables, get in touch with your nearest American Steel & Wire Company office.

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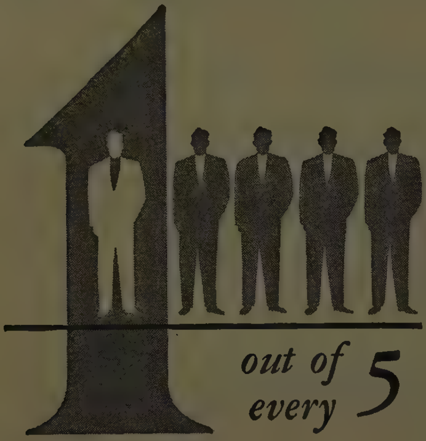
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

American Electrical Wire & Cable

UNITED STATES STEEL

SELENIUM RECTIFIERS



Here at International Rectifier Corporation, we take our engineering seriously. As a result, one out of every 5 of our employees is a carefully trained, graduate engineer. That means intelligent control of quality from design to finished product. That also means, when you specify International R. C. Rectifiers, you get peak performance and long life.

You can put this engineering organization to work for you without adding one cent to your payroll. International R. C. engineers will cooperate with your staff in developing the correct Rectifier for your job and in producing them in the quantity you need.

TYPE W-HS-SERIES
75 Milliamperes DC
In 1¼" Phenolic Tube with stud mounting at each end. Circuit-Half-Wave. Overall length varies to 14", depending on DC Output Voltage rating. For many applications for heavier duty and inverse peak suppressor circuits.

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DESIGNED TO MEET DIFFICULT HUMIDITY, ALTITUDE, VIBRATION AND SHOCK SPECIFICATIONS.

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W-HS SERIES

DC Output Voltage	Rectifier Part No.
20	W1HS
60	W3HS
100	W5HS
400	W20HS
800	W40HS
1500	W75HS
2500	W125HS
3500	W175HS
4500	W225HS
6000	W300HS

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INDUSTRIAL NOTES ....

Cannon Electric Changes Name; Opens New Plant. The Cannon Electric Development Company, Division of the Cannon Manufacturing Corporation, has changed its name to the Cannon Electric Company. The company has recently opened a new plant at 191 Kimberly Street, East Haven, Conn. E. C. Quackenbush has been made head of the Engineering Department of this new eastern division. Cannon has also appointed a new advertising agency, Hixson and Jorgensen, Inc., Los Angeles, Calif., to succeed the Dana Jones Company.

Kerite Names Two Directors. Arthur H. Smith and Franklin S. Harris were named to the Board of Directors of The Kerite Company. Both men are Vice-Presidents of the firm.

Minnesota Mining and Manufacturing Plans $6,500,000 Expansion. The Minnesota Mining and Manufacturing Company has begun work on its $6,500,000 plant expansion program. Most of the projects, located in Atlanta, Ga., Bristol, Pa., Buffalo, N. Y., Cleveland, Ohio, Lemont, Ill., Wayne, Mich., Boston, Mass., and Hastings, Hutchinson, and St. Paul, Minn., are already under way.

Cornell-Dubilier Appointment. Emil J. Maginot has been made manager of advertising for the Cornell-Dubilier Electric Corporation.

Honeywell to Work with Westinghouse. The Minneapolis-Honeywell Regulator Company has completed arrangements to perform consulting services to the Atomic Power Division of the Westinghouse Electric Corporation. Under the agreement, Honeywell engineers will act as consultants in valve problems arising in the Westinghouse program.

All America Cables and Radio Names Vice-President. L. N. Anderson has been elected a Vice-President of All America Cables and Radio, Inc., and Mackay Radio and Telegraph Company, subsidiaries of the American Cable and Radio Corporation. Mr. Anderson is also a Vice-President of The Commercial Cable Company, another American Cable and Radio subsidiary.

Kollsman Appoints Vice-President, Treasurer, and Secretary. Alan G. Binnie has been made Vice-President, Lowell H. Freye, Treasurer, and Arthur Richenthal, Secretary of the Kollsman Instrument Corporation, now a wholly owned subsidiary of Standard Coil Products Co., Inc.

Sylvania Reorganizes Midwest Lighting Division. The lighting sales central division of Sylvania Electric Products, Inc., has been reorganized into three separate divisions to be known as the Chicago division, with headquarters in that city; the St. Louis Division, with headquarters in St. Louis; and the Milwaukee division, with temporary headquarters in Chicago. The change has been made to facilitate coverage of the entire central area. The Lighting Sales Department of Sylvania has also organized a new division office and warehouse operation in Dallas, Tex. T. J. Ewbank has been made manager.

Du Mont Appointment. James L. Emaus has been named sales application engineer, Sales Department, electronic parts division, Allen B. Du Mont Laboratories, Inc.

A. H. Taylor, W. C. Noll Retire; Other G-E News. A. Hadley Taylor, physicist on the Engineering Department staff of the General Electric Company's lamp division at Nela Park, has retired after 30 years' service. Mr. Taylor specialized in the field of lighting research. William C. Noll, manager of the technical and education section, product service division, also has retired, after nearly 45 continuous years of service with the company.

General Electric has also announced the following new appointments: William F. Oswalt and Frank T. Gamec, assistant manager of manufacturing and production manager, respectively, control divisions; William B. Gillen, manager, East Cleveland Lamp Works; W. E. Blowney, divisions engineer, steam turbine, generator, and gear engineering divisions; L. B. Wales, division engineer, auxiliary turbine engineering division; Elmer F. Paul, manager of manufacturing, specialty transformer and ballast divisions; Donald Poland, manager, Danville, Ill. plant; and C. W. Michaels, supervisor of market research, commercial equipment division.

Allis-Chalmers Opens New Peoria Office; Appointments. Stanley E. Bovim has been made manager, and F. D. McGuire, Jr., sales representative, of a new branch office of the Allis-Chalmers Manufacturing Company's general machinery division in Peoria, Ill. The company has also named Charles W. Bloedorn as southeast regional representative, Steam Turbine Department, Atlanta, Ga. Newly named Allis-Chalmers general machinery division sales representatives are: Arthur E. Schnaufer, Duluth, Minn.; Robert R. Maxwell, Davenport, Iowa; R. F. Kinney, Kansas City, Mo.; John T. Petersen, Cleveland, Ohio; William H. Davis, Cincinnati, Ohio; William R. Carlyon and Clare K. Tubbs, Detroit, Mich.; Jack H. Doty, Jackson, Mich.; Charles Watson, Boston, Mass.; Donald A. Wooley, New York, N. Y.; John E. Watson, Birmingham, Ala.; James P. Boger, Charlotte, S. C.; Stephen Hogg, Jr., Atlanta, Ga.; Wilson O. Vaughn, Richmond, Va.; and Loren D. Barre, Portland, Oreg.

Emerson Electric Elections. The Emerson Electric Manufacturing Company has

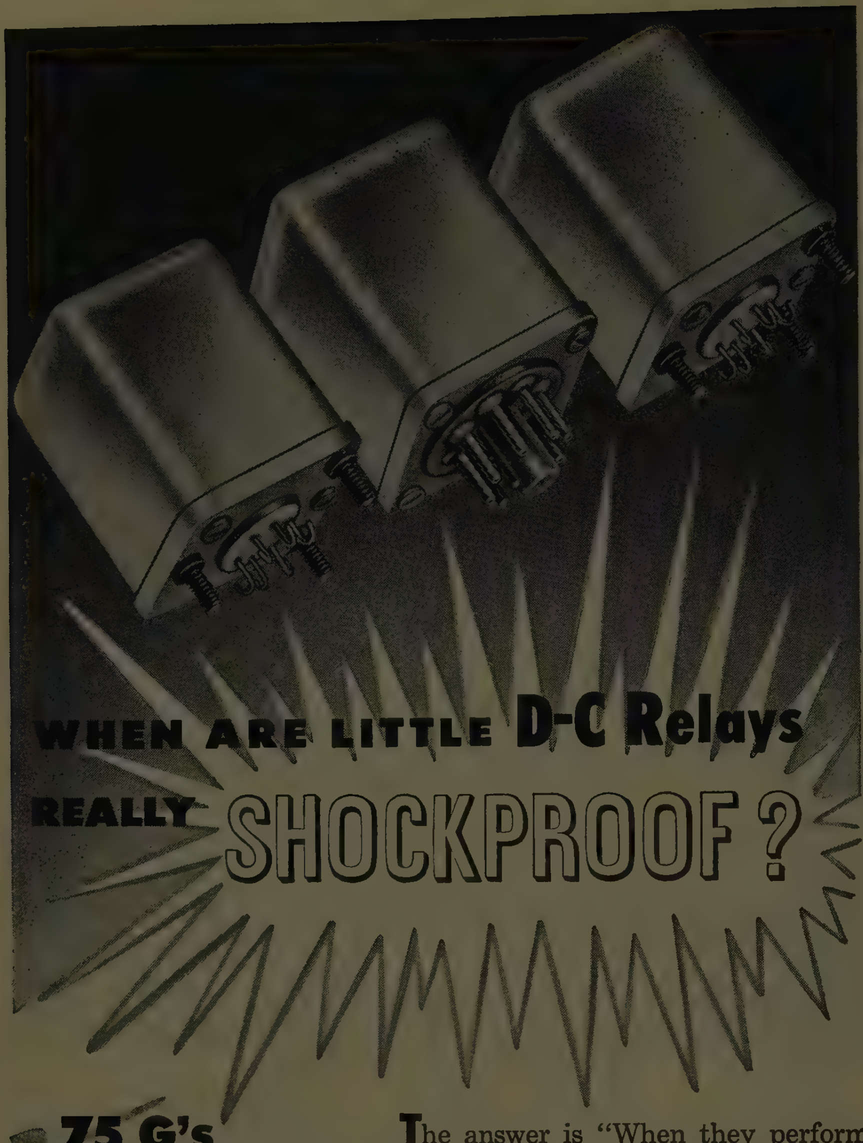
(Continued on page 26A)

at this Eastern Plant

Modern G-E Metal-clad Switchgear now installed at the Traylor Company provides greater safety because all parts are completely enclosed. For greater protection against short circuits, separate circuits are isolated in individual compartments. Circuit breakers may be easily removed for inspection, with protection for personnel. Power is distributed from this unit at 2400 volts, replacing the old 240-volt distribution system.

Load-center Unit Substation eliminates long low-voltage feeders—saves copper. 2400-volt power is received at this load-center unit substation and stepped down to utilization voltage on the factory floor. Because the substation is located close to the machines it serves, low-voltage feeders are short, saving copper and giving better voltage control. Discarded cable previously used for low-voltage distribution is shown at left.

GENERAL ELECTRIC



75 G's MECHANICAL SHOCK

25 G's OPERATING SHOCK

15 G's VIBRATION

The answer is "When they perform dependably under the conditions of shock and vibration for which they are recommended."

That means you can safely use these little multipole d-c relays on a wide variety of portable, mobile, aircraft, ship and commercial applications where shock does not exceed the exceptionally broad limits indicated at the left. *Write for Struthers-Dunn Data Bulletin 2610.*

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MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PITTSBURGH
ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

(Continued from page 18A)

announced the following company elections: Henry C. Miller, Vice-President and general works manager; Raymond E. Otto, Vice-President and general sales manager; Ralph E. Petering, Vice-President and Assistant Treasurer; and Byron W. Jackson, comptroller and assistant secretary.

Lenkurt Names Engineering Representative. The Lenkurt Electric Company has appointed Edward G. Hall as engineering representative, Sales and Engineering Service Department.

Westinghouse Appointments. Mark W. Cresap, Jr., has joined Westinghouse Electric Corporation as a Vice-President and assistant to President Gwilmy A. Price; Harry A. Hillman has been named director of employment costs; Henry R. Michel has been made assistant to Andrew H. Phelps, Vice-President in charge of purchases and traffic; Harry L. Niederauer has been appointed manager of advertising and sales promotion; and Charles H. Atkin has been made supervisor of industrial relations.

NEW PRODUCTS • •

Function Plotter. The automatic compiling of two measurements and plotting of a curve to show their interrelationship, namely, $Y = f(X)$, is made possible by a new electronic instrument, the Brown ElectroniK Function Plotter. Developed by the Brown Instruments Division of the Minneapolis-Honeywell Regulator Company, Wayne and Windrim Avenues, Philadelphia 44, Pa., the instrument incorporates two measuring systems, one of which actuates the recorder pen while the other motivates the instrument chart. With this arrangement the chart is driven up and down in response to the changes in one variable simultaneously with the movement of the pen in response to changes in a second variable. The result is a curve which continuously evaluates one variable in terms of the other. Further information is available from the company.

900-Megacycle Transmitting Tube. The General Electric Company has introduced a new 1-kw 900-megacycle ceramic transmitting tube—the *GL-6019.* A 4-electrode power tube, the *GL-6019* was designed for use as a class-*B* broadband amplifier and as a class-*C* amplifier or oscillator. In both cases, grids are at radio frequency ground. Special features include safe operation at 200-degree centigrade operating temperatures (due to metal and ceramic construction and the use of high melting-point solders); reduced seal electrolysis; minimum electrical loss at contacts (due to gold over silver plating on external metal parts); outside water connections; reduced grid emission (because of platinum-clad molybdenum grid construction); and a grounded-grid tetrode

(Continued on page 36A)

ENGINEERING

as a

CAREER

A MESSAGE TO YOUNG MEN, TEACHERS AND PARENTS

✦

This pamphlet has been prepared as an educational guide, in order to give something of an introductory insight into the profession of engineering. It is dedicated to the coming generation of engineers and to the constructive contributions which they will make to the life and culture of mankind. Contents of the booklet have been divided into three main parts: The Scope of Engineering; Principal Branches of Engineering; and References to Vocational Guidance Literature.

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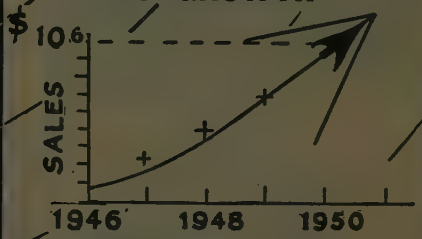

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MAKING
A SMALL COMPANY
WITH A BIG
FUTURE!

Standard
RADIO INTERFERENCE
and FIELD INTENSITY
Measuring Equipment
Complete Frequency Coverage - 14kc to 1000mc!

VLF!
NM - 10A
14kc to 250kc
Commercial Equivalent of AN/URM-6.
Very low frequencies.

HF!
NM - 20A 150kc to 25mc
Commercial Equivalent of AN/PRM-1. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies.

VHF!
NMA - 5
15mc to 400mc
Commercial Equivalent of TS-587/U.
Frequency range includes FM and TV Bands.

UHF!
375mc to 1000mc NM - 50A
Commercial Equivalent of AN/URM-17.
Frequency range includes Citizens Band and UHF color TV Band.

These instruments comply with test equipment requirements of such radio interference specifications as JAN-I-225, ASA C63.2, 16E4(SHIPS), AN-I-24a, AN-I-42, AN-I-27a, AN-I-40 and others.

STODDART AIRCRAFT RADIO CO.
6644-B SANTA MONICA BLVD., HOLLYWOOD 38, CALIFORNIA
Hillside 9294

(*Continued from page 26A*)

circuit. Additional details may be obtained from the Tube Division, General Electric Company, 570 Lexington Avenue, New York 22, N. Y.

Calculating Machine. Facit, Inc., newly established American subsidiary of Aktiebolaget Atvidabergs Industrier of Stockholm, Sweden, has introduced a new calculating machine. Controlled by a 2-bank keyboard with only ten digits, the Facit machines revolve forward for the figures one to five and backwards for the figures six to nine. Four models are available: the Facit *TK*, a small hand-operated calculator, handles the four basic mathematical processes; the Facit *Lx*, also manual, has a larger capacity than the *TK;* the Facit *NEA*, an electric calculator with automatic division and semiautomatic multiplication; and the Facit *ESA-O*, fully automatic for calculations where higher speed is essential. Further details are available from Facit, Inc., 500 Fifth Avenue, New York 18, N. Y.

Explosion-Proof Starters. The Arrow-Hart and Hegeman Electric Company has announced a new line of explosion-proof weatherproof magnetic starters. Smaller and lighter in weight than other units, the starter features Feraloy cast housing in combination with a right-angle design mechanism. Terminals and contacts are accessible from the front; line and load may be completely separated; circuits immediately identified. For more complete information, write Industrial Control Division, The Arrow-Hart and Hegeman Electric Company, 103 Hawthorn Street, Hartford 6, Conn.

"New Look" Television Transmitter. A new line of amplitude-modulated 5-kw transmitters which can be stepped up to 10-kw output with slight modifications has been announced by the RCA Victor Division of the Radio Corporation of America. This transmitter, RCA type *BTA-5G*, has fewer tubes and fewer tube types than previous models, and is housed entirely (except for the high-voltage plate transformer) in four lightweight cabinets installed side-by-side on two 4-inch wire troughs which run the full length of the transmitter. Sliding doors which do not extend beyond the transmitter cabinets contribute to a big saving in floor space. There are two oscillator units, each of which maintains its frequency within ± 5 cycles. Absence of air-dielectric capacitors in the transmitter reduces arc-over possibilities due to dust collection. All radio-frequency stages are designed for class-*C* operation; low audio distortion at frequencies from 50 to 10,000 cycles is achieved at all percentages of modulation by modulating the radio-frequency driver as well as the power amplifier. Any further information on the *BTA-5G* transmitter may be obtained from the company at Camden, N. J.

Statistical Analyzer for Potentiometers. To obtain figures for mathematical analysis of the over-all performance of potentiom-

(*Continued on page 42A*)

Your Voltage

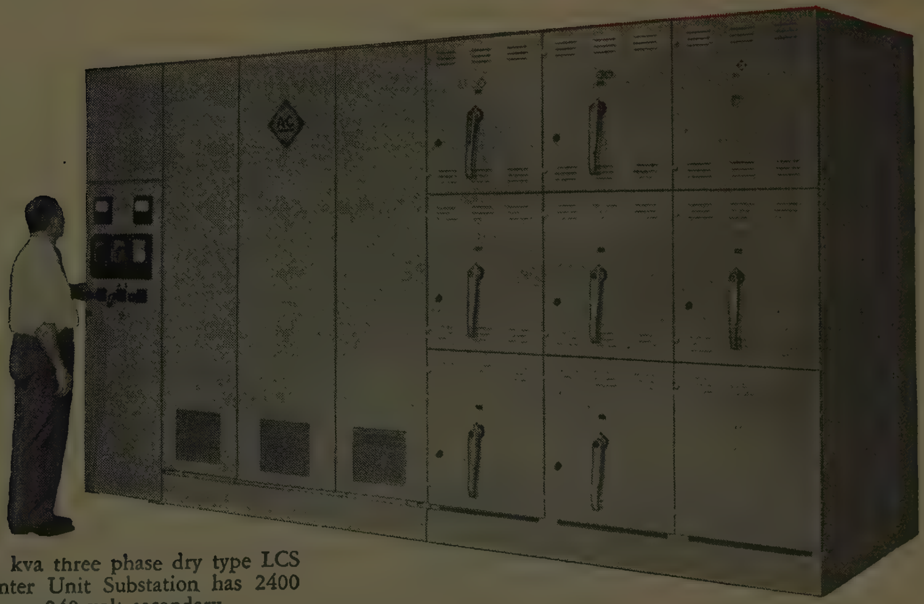
STOP WASTING MANHOURS on slow producing machines. Get the most from the production equipment in your plant by installing unit substations to correct undervoltage. No electrical equipment gives top performance *unless* it operates at rated voltage . . . and even well designed distribution systems may prove inadequate because of today's added loads and increased production schedules.

For example, if your squirrel-cage motors operate at 10% undervoltage, maximum torque available to start machinery is reduced 19% . . . heating effect within the motors is inceased 21% . . . overload capacity falls, efficiency drops.

Increase your output by eliminating production slow-downs resulting from overloaded motors . . . machine down-time due to tripped starters or circuit breakers. Install Allis-Chalmers LCS Unit Substations at load centers and eliminate excessive line drop by shortening low voltage cables. Allis-Chalmers LCS Load Center Unit Substations are neat, compact, easy to install, and provide protection to personnel.

You can count on the cooperation of experienced Allis-Chalmers substation engineers in working out your distribution system. Get in touch with your A-C representative, or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for bulletins 11B6285A, 11B6325B and 11B6895. A-3371

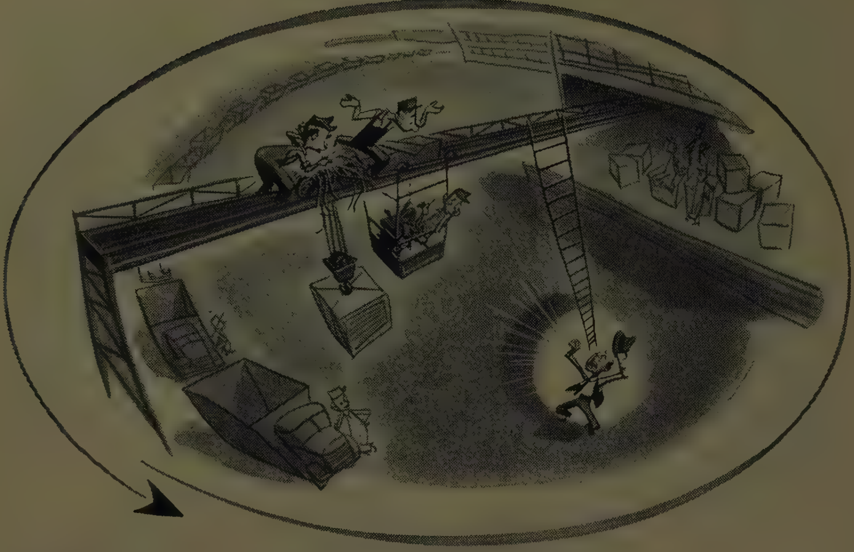
ALLIS-CHALMERS
LCS
LOAD CENTER
Unit Substation



This 750 kva three phase dry type LCS Load Center Unit Substation has 2400 volt primary, 240 volt secondary.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS



Burned-out Motors Waste Manpower!

Men without motors are just about as helpless in a modern factory as a wagon without wheels on a superhighway.

In many plants the failure of a single motor used to drive an overhead crane or a conveyor system can cost thousands of dollars an hour in lost production and wasted man-hours of labor.

The answer is Class H insulation made with Dow Corning Silicones. In a steel mill, for example, a cupola crane hoist motor insulated with the best Class B materials had an average life of only 50 days. Rewind costs alone amounted to $3,634 in three years. That motor, rewound with Class H Insulation at an extra cost of only $79 was still in good condition after 613 days on the hoist and 908 days on the trolley bridge.

And Class H is readily available. Most of the best rewind shops now feature this longer lasting, more reliable class of insulation. Leading motor manufacturers are quoting price and delivery on new Class H machines.

Dow Corning Silicones Mean Business!

MAIL THIS COUPON TODAY!

DOW CORNING CORPORATION, MIDLAND, MICHIGAN
Please send me ☐ More Evidence ☐ List of Class H Rewind Shops ☐ List of Motor Manufacturers Offering New Class H machines. H-6
Name__________
Company__________
Street__________
City__________ Zone_____ State______

DOW CORNING
SILICONES
DOW CORNING CORPORATION

BRANCH OFFICES: ATLANTA • CHICAGO • CLEVELAND • DALLAS • LOS ANGELES
NEW YORK • WASHINGTON, D. C. • In CANADA: Fiberglas Canada Ltd., Toronto
In GREAT BRITAIN: Midland Silicones Ltd., London.

(*Continued from page 36A*)

eters used in analogue computers, Avion Instrument Corporation has developed an instrument to provide information in three minutes that might require hours of ordinary test procedure. It determines statistical distribution of error rather than peak error alone. By knowing the error distribution, it is often possible to broaden tolerances to aid in procurement and production. The instrument consists of a calibrated reference potentiometer, having a peak error of less than two per cent full scale. It is driven on a common shaft with the potentiometer on test. Voltage is applied to both potentiometers. The voltage difference received from the standard and test potentiometer provides an error signal which is fed through a d-c servo mechanism. This positions a brush on a commutator. Angular displacement of the brush gives information on the magnitude and duration of each error. Commutator segments are connected to eight electrically operated counters which register 1,000 measurements made during one complete rotation of the potentiometers. Four counters show the positive and four the negative errors. Data, taken from the counters, may be plotted on a curve showing error value versus error frequency. Power requirements are 115 volts 60 cycles per second, and 6.3 volts 400 cycles per second. Further information may be obtained from Avion Instrument Corporation, 121 East 24th Street, New York 10, N. Y

Tube Tester. A new Triplett tube tester, model *3413-A*, will check any type radio-receiving tube, miniature hearing-aid tubes, pilot lamps, flashlight bulbs, and television picture tubes. The tester gives both a short- and open-circuit check of each element of every tube; television tubes can be checked without removing them from the receiver by use of an adapter that may be purchased separately. Filament voltage is 0.63 volt to 110 volts in 14 steps: power is 115 volts, 50–60 cycles alternating current. Complete details may be obtained from the Triplett Electrical Instrument Company, Bluffton, Ohio.

Subminiature Paper Capacitors. Available as standard for the first time are hermetically sealed subminiature threaded-neck, side-stud and end-stud capacitors, as well as vertical and horizontal bracket mounting units. Developed by the Sprague Electric Company, these new mounting arrangements are intended to help equipment designers overcome vibration and shock problems encountered when mounting capacitors by wire leads in military gear. The 125-degree-centigrade continuous-operating-temperature capacitors use vitamin Q, Sprague's organic polymer capacitor impregnant. These subminiature units are available in voltage ratings from 100 to 1,000 direct volts in both inserted tab and extended foil constructions. Complete details are contained in bulletin *213A*, which is available from the Sprague Electric Company, North Adams, Mass.

(*Continued on page 48A*)

IDDLE

Instrument News

• ELECTRICAL TESTING INSTRUMENTS
• SPEED MEASURING INSTRUMENTS
• LABORATORY & SCIENTIFIC EQUIPMENT

NUMBER 7 OF A SERIES

JAMES G. BIDDLE CO., 1316 ARCH ST., PHILADELPHIA 7, PA.

OTOR DRIVEN "MEGGER®" INSULATION TESTERS

anges up to 50,000 megohms at 2500 volts D-C.

USES

Where a number of tests are made at one location, as in testing separate conductors in telephone cable.

For dielectric absorption measurements on the insulation of generators, transformers and cables.

Where high resistance values need to be measured continuously, such as for indicating the moisture content of paper in production.

As a convenient source of low energy test potential at comparatively high d-c voltages.

Motor-driven "Megger" Sets are simple o operate, direct-readings by pointer eflection, rugged and portable; and they re of sufficient range and accuracy for ost practical purposes.

DESCRIPTION

The motor-driven "Megger" Insulation Tester is similar to the well-known hand-operated set except that the d-c generator is driven by a motor which can be connected to a convenient outlet.

The generators in motor-driven sets have bearings and other features properly designed for motor operation. They are for continuous, or 24-hour duty. The driving motors which are rubber-mounted to reduce vibration are usually rated 1/20 hp, 115 volts, 60 cps. Other voltage and frequency ratings can be supplied.

The motor and its supporting bracket can be removed quite easily from the instrument case and the set made available for hand operation where an external source of current may not be available. This change can be made in the field.

For complete information write for *Bulletin 21-20-EE.*

Photo courtesy Philadelphia Electric Co.

ELECTRICAL MEN IN INDUSTRY PREFER THIS DEPENDABLE AND RUGGED INSULATION TESTER

For average industrial requirements the Meg type of Megger® Insulation Tester is by far the most popular set we supply. This incomparable "trouble shooter" has ranges up to 2000 megohms with hand generators up to 1000 volts d-c. It is also supplied with a plug-in rectifier power supply either instead of or in addition to the hand generator.

The performance and endurance records which these instruments have achieved are difficult, if not impossible, to match in any type of portable testing device. For insulation resistance measurements—"Megger" instruments are the recognized standard.

Anyone can measure electrical insulation resistance in generators, motors, wiring and other electrical equipment with a Megger instrument—quickly—easily. Simply make connections, turn the crank and read the position of the pointer on the scale—no dependence on batteries or other source of test current; the built-in generator is always a ready and dependable source of supply.

Learn more about these "indispensable" tools today by writing for *Bulletin 21-45-EE.*

HERE'S A "GOOD COMPANIONS" KIT FOR PRACTICAL ELECTRICAL ENGINEERS AND MAINTENANCE MEN

Men concerned with all-around-the-plant electrical tests and resistance measurements tell us that these are "indispensable" tools:

Midget Megger® CVM constant voltage type of Megger® Insulation Tester for detecting dirt, moisture and deterioration in advance of failure, or as a trouble-shooter after failures occur.

The Midget Megger Circuit Testing Ohmmeter for measuring conductor resistance of coils, contacts and relays, and checking continuity of circuit and grounded parts.

Be sure to write for your copy of 21-85-EE today.

DEPENDABLE

OUTDOOR BUS SUPPORTS and FITTINGS...

Insure Continuity of Service

THE MOST COMPLETE LINE

- BRONZE BUS SUPPORTS FOR USE WITH COPPER CONDUCTORS
- ALUMINUM BUS SUPPORTS FOR USE WITH ALUMINUM CONDUCTORS
- *Available with and without insulators*

Anderson Brass has made a specialty of assisting with solving "tough" substation bus support and connector problems. This specialty transcends all phases of electrical, mechanical and metallurgical problems.

With more than two decades of specialized electrical, mechanical and metallurgical experience in the engineering and manufacture of bus supports, fittings and connectors we are qualified to assist in improving your substation's dependability and circuit security with no extra cost. This type of service is at your disposal from Anderson Brass. We welcome the "tough" problems as well as the "easy" ones.

Consult one of our nearest 19 representatives or contact our main office.

ABW

Write today for Catalog No. 205—Outdoor Bus Supports and Fittings. Information on aluminum bus supports and fittings available on request.

ANDERSON BRASS WORKS, INC.
POST OFFICE DRAWER 2151
BIRMINGHAM, 1, ALABAMA

- BRONZE AND ALUMINUM POWER CONNECTORS, FITTINGS, AND BUS SUPPORTS
ALUMINUM SUSPENSION AND STRAIN CLAMPS

(*Continued from page 42A*)

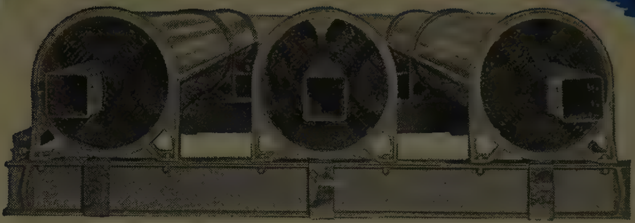
Midget Moisture Meter. The *TA*
midget moisture meter, specially designe
for instantly determining the moistu
content of wood, lumber, plaster, a
wood products, has been announced by t
Tagliabue Instruments Division, Depa
ment 67, Weston Electrical Instrume
Corporation, 614 Frelinghuysen Avenu
Newark 5, N. J. The meter measur
moisture by the electrical resistan
method, which is based upon the fact th
the resistance of wood, measured betwe
accurately spaced electrodes with corre
needle penetration and at a fixed potenti
varies proportionally with the moistu
present in the wood. Readings can
taken directly in per cent moisture, wi
no reconversion tables or laboratory te
necessary. Further details on the moistu
meter are contained in bulletin *12*
which may be obtained upon request fro
the company.

Rotary Selector Switch. The Leeds a
Northrup Company has announced a ne
rotary selector switch for use in instrume
circuits. The contact resistance of
new switch is about 0.001 ohm, and chang
less than 0.0005 ohm on life tests
10,000,000 operations. Stationary conta
are made of solid silver. Thermal elec
motive force is less than one microv
when the switch is operated at norm
speed, making the switch suitable for lo
level circuits. Maximum inductance
less than 0.03 microhenry, and capacitan
between segments is less than 0.5 mic
microfarad. Insulation withstands 5
volts rms between segments and fr
segments to ground. Current interrupti
capacity is one ampere at 110 volts
cycles on resistance load. Contacts ca
continuous current of five amperes. F
details, write to The Leeds and North
Company, 4934 Stenton Avenue, Phi
delphia 44, Pa.

Electronic Strainalyzer. An instrume
for the study of vibration, strain, a
dynamic stresses has been introduced
the Electronic Tube Corporation, 12
East Mermaid Lane, Philadelphia 18,
Known as the *H-42A* Strainalyzer, the u
records phenomena up to 50 kc a
amplifies these weak signals up to 35,0
times. It makes possible the simultane
observation and recording of four separ
traces on a single 5-inch oscilloscope tu
each appearing in correct time relations
without the necessity of optical alignme
As a typical application, the Strainaly
can be used to check relative pressures
four different points of a gun barrel.
rocket and jet-engine testing or resear
firing cycle, chamber pressure, thrust, a
temperature may all be recorded sim
taneously, and will appear simultaneou
on a 5-inch screen for absolutely cor
time and phase relationship. Recording
the unit is accomplished with a Fairch
Oscillo-Record camera. Other uses
this instrument range from strain, str
and vibration studies in such equipm
as aircraft and automotive units to pres

(*Continued on page 52A*)

EQUIREMENTS FOR A SET OF GENERATOR LEADS



ELECTRICALLY, THEY MUST

- carry the output with but one conductor per phase.
- not exceed a reasonable temperature rise.
- withstand overload without harmful effect to the conductor or its insulation.
- have a tight cover to prevent short circuiting by dust, moisture, etc., on the creepage surfaces of the insulators.
- have a minimum of bolted connections in bus run.
- protect against phase-to-phase short circuits.
- have insulation which is not harmed by heat or age.

MECHANICALLY, THEY MUST

- provide for expansion of bus and cover due to heat.
- withstand vibration.
- be adaptable to installation in congested areas.
- withstand thermal and mechanical stresses without damage or operating failure.
- employ porcelain and metals to their best advantage.

WHEN INSTALLED, THEY MUST

- present an attractive appearance.
- be easily put in place.

FOR INSPECTION AND MAINTENANCE, THEY MUST

- be easily accessible, permitting quick replacement of parts, particularly insulators.
- withstand periodic high-potential tests without damage to insulation.
- protect personnel who may come in contact with bus enclosure.

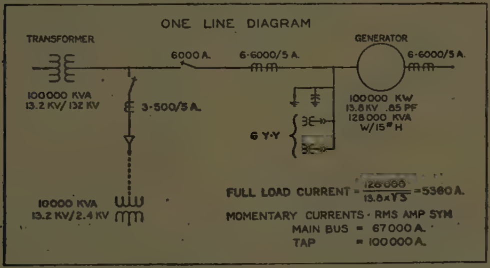
FOR ASSOCIATED EQUIPMENT, THEY MUST

- make provision for mounting disconnecting switches, instrument transformers, and protective devices.

I-T-E ISOLATED PHASE BUS MEETS ALL THESE REQUIREMENTS!

And it's as easy as this to order!

1. Give us a one-line diagram, like this —

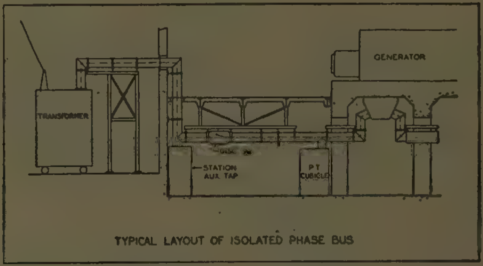


$$\text{FULL LOAD CURRENT} = \frac{128000}{13.8 \times \sqrt{3}} = 5360\text{ A.}$$

MOMENTARY CURRENTS - RMS AMP SYM
MAIN BUS = 67000 A.
TAP = 100000 A.

2. Plus pertinent information about your building, generator, and transformers.

3. We will quote —



4. And then build *your* Isolated Phase Bus.

For further information, see your local I-T-E Representative, or write

ISOLATED PHASE BUS STRUCTURES

I-T-E Circuit Breaker Company • 19th and Hamilton Streets • Philadelphia 30, Pa.

Power Switching Equipment: Railway and Industrial Engineering Co., Greensburg, Pa.

Canadian Mfg. [illegible] Eastern Power Devices, Ltd., [illegible] Export Sales: Philips Export Corp., New York

R&IE

WITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • CIRCUIT BREAKERS • MECHANICAL RECTIFIERS • RESISTORS • SPECIAL PRODUCTS

MARCUS
DRY TYPE TRANSFORMERS
exclusively!

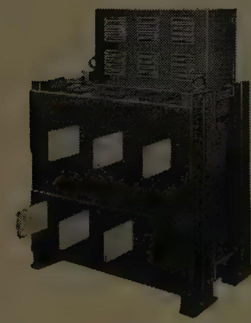
THE MARK OF QUALITY MTC

TYPE ACO

All purpose, indoor or outdoor, dry type distribution transformers. Sizes to 100 KVA, voltages to 5000 V.

TYPE C

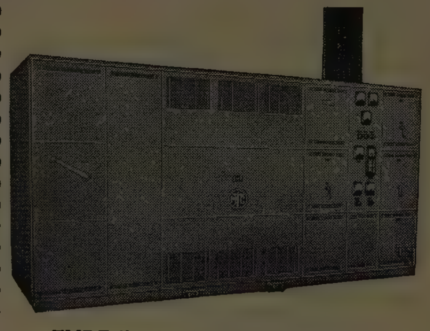
General purpose transformers, 600 volts and below; 1-15 KVA inclusive, single or three phase completely self contained.



FURNACE TRANSFORMER

3 PHASE, 3/2 PHASE, 1 PHASE

Uses—Forging, heat treating, melting, resistance heating, welding, etc.



TYPE F - UNIT SUBSTATION

1000 KVA, 4160Y 60 Cycles, 3 Ø —480 delta; Fused, load interrupter on H.V. (left). Drawout type breakers and metering equipment on L.V.

ONE OF THE WORLD'S LARGEST MANUFACTURERS OF DRY TYPE TRANSFORMERS *EXCLUSIVELY*

1 to 2,000 KVA up to 15,000 Volts to meet Individual Requirements

- DISTRIBUTION
- GENERAL PURPOSE
- UNIT SUBSTATION
- PHASE CHANGING
- ELECTRIC FURNACE
- RECTIFIER
- WELDING
- MOTOR STARTING
- SPECIAL

MTC produces a complete line of quality transformers to 2000 KVA. A newly expanded plant with the most modern equipment, plus a background of years of dry type specialization, assures maximum transformer value.

NEMA

MARCUS TRANSFORMERS CONFORM TO THE STANDARDS OF N.E.M.A. AND A.I.E.E.

Representatives in Principal Cities

MARCUS
TRANSFORMER CO.
INC.
32 MONTGOMERY STREET
HILLSIDE 5, NEW JERSEY

PIONEERS IN THE FIELD OF AIR-COOLED TRANSFORMERS

(*Continued from page 48A*)

internal combustion engines, all rotating and reciprocating mechanisms, and many others. This model, *H-42A*, is designed for d-c bridge excitation from self-contained batteries and has the necessary high-gain d-c amplifiers, balance controls, and voltage and calibration controls for each strain gauge bridge channel. Also, the instrument is not acoustically sensitive—when operated within 15 feet of the firing of a 400-pound rocket with only a blast wall between, no microphonics are detectable. A bulletin giving full details of the Strainalyzer will be sent on request to the company.

TRADE LITERATURE

Instrument Transformers. A 93-page brochure, *GEA-4626*, containing technical information on General Electric instrument transformers has been announced as available from the Meter and Instrument Divisions, General Electric Company, Schenectady 5, N.Y.

Electronic Parts. A 130-page catalogue of radio, television, and electronic components has been published by Sun Radio and Electronics Company, Inc., 122–12 Duane Street, New York 7, N. Y. It may be obtained upon request.

Synchronous Generators. The Allis-Chalmers Manufacturing Company has issued a 32-page booklet, *05B7549*, on hydraulic turbine-driven synchronous generators and large vertical motors which is available from the company at 931 South 70th Street, Milwaukee, Wis.

Connectors and Installation Tools. A 24-page catalogue describing Hydent electric connectors and installation tools has been published by the Burndy Engineering Company, Inc., New York 54, N. Y. The catalogue, number *Y53*, may be obtained upon request.

Technical Sound Films. Seventy-two sound films which cover general interest subjects, product information, and training and instruction courses are listed in a new 1951 catalogue, *B-4761*, available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa. All films listed are loaned free to organized groups, such as professional, civic, and business.

Nickel Cadmium Battery. The alkaline nickel cadmium storage battery is described in a bulletin published by Nife Inc., 165 Broadway, New York 6, N. Y. The bulletin, number *1-1053-E*, may be obtained upon request.

Fluid Flow Rate Testing. A technical report, *A-9C-4*, containing data on the newest technical developments on fluid flow rate testing for the aviation industry is available from the Fischer and Porter Company, 3780 County Line Road, Hatboro, Pa.

(*Continued on page 56A*)

Vital Station Interconnections Get Maximum Protection

isolated-phase bus

Vith G-E isolated-phase bus runs for vital interconnections etween generators, transformers and main switchgear, you now that every precaution is taken to insure freedom from aults of every type. Dust-tight, weather-tight aluminum onstruction seals out many possible causes of flashover. dvanced G-E design reduces the number of creepage suraces without sacrifice of mechanical strength. Supplied in ither individual-phase sections or as a complete three-phase ackage, G-E isolated-phase buses simplify installation problems and cut costs.

Your G-E sales representative has complete information. sk him for a copy of GEA-5460, a 28-page publication that ill aid you in planning your buses, or write to General lectric Company, Schenectady 5, N. Y.

Typical three-phase section of G-E isolated-phase bus. Bus is copper, channel-type to provide maximum strength. Silver contact surfaces assure full flow of current and eliminate oxidation troubles. Insulators conform to NEMA standards, are normally carried in stock in power stations. Gasketed, aluminum cover has two sets of hinges to permit opening from either side. Lugs release covers without removal of any bolts. End bells are welded to housing. Adjacent ring flanges are tightly joined by split aluminum bands whose mating edges are also gasketed.

855-26

GENERAL ELECTRIC

BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT — CARBON, GRAPHITE and PRECIOUS METAL CONTACTS — BATTERY CARBONS — BEARING MATERIALS — BRAZING FURNACE BOATS — CARBON PILES — CLUTCH RINGS — CONTINUOUS CASTING DIES — DASH POT PLUNGERS — ELECTRIC FURNACE HEATING ELEMENTS — FRICTION SEGMENTS — GLASS MOLDS — MERCURY ARC RECTIFIER ANODES — METAL GRAPHITE CONTACTS — POWER TUBE ANODES — RAIL BONDING MOLDS — RESISTANCE WELDING and BRAZING TIPS — SEAL RINGS (for gas or liquid) — SPECIAL MOLDS and DIES — TROLLEY and PANTOGRAPH SHOES — WATER HEATER and PASTEURIZATION ELECTRODES — ANODES FOR ELECTROLYSIS — WELDING CARBONS, etc.

STACKPOLE

STACKPOLE CARBON COMPANY
St. Marys, Pa.

(*Continued from page 52A*)

Lathe Handbook. The revised edition of the lathe operator's handbook, "How to Run A Lathe," is available in paper binding at $0.25 or in imitation leather fabrikoid binding at $1.00 a copy postpaid. The 128-page booklet may be obtained by writing to the South Bend Lathe Works, South Bend 22, Ind.

Corrosion Resistance Computer. A pocket-size computer that quickly tells which proper nonferrous or stainless steel alloys to use for 142 corrosive situations is offered upon request to The H. M. Harper Company, 8200 Lehigh Avenue, Morton Grove, Ill.

High-Frequency Power Resistor. A high-frequency, high-power resistor for television, frequency modulation, and dielectric heating applications is described in bulletin *F-2*, available from the International Resistance Company, 401 North Broad Street, Philadelphia 8, Pa.

Transformer Catalogue. The new 1951 36-page edition of the Stancor television transformer catalogue and replacement guide is now available from the Standard Transformer Corporation, 3580 North Elston Avenue, Chicago 18, Ill.

Viscorator Instruments. Viscorator instruments, which provide an instantaneous method for determining viscosity values for industrial processes, are described in catalog *88*, which may be obtained upon request from the Fischer and Porter Company, 4030 County Line Road, Hatboro, Pa.

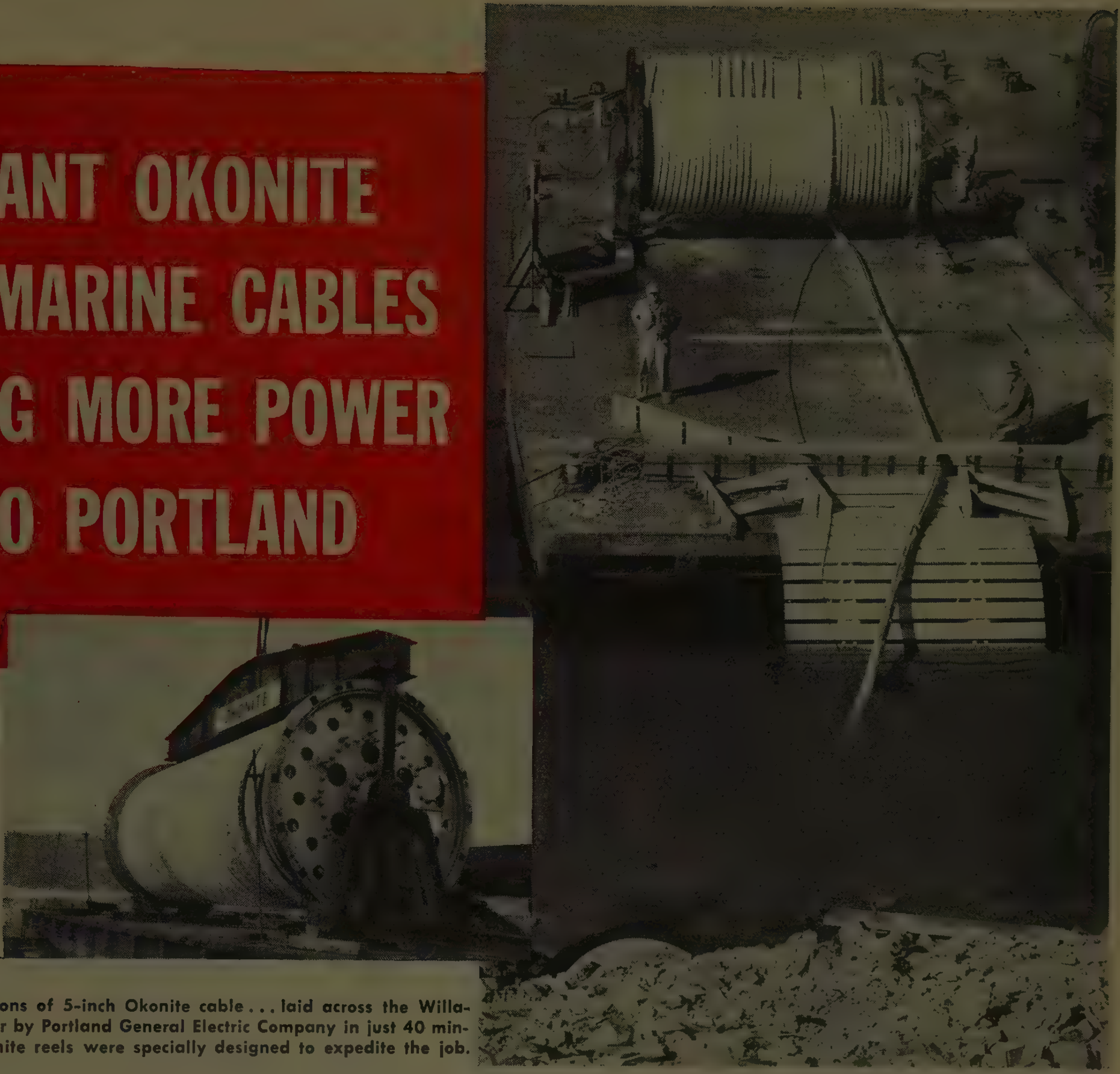
Professional Recording Equipment. The RCA Victor Division of the Radio Corporation of America has released a 20-page brochure describing RCA's latest professional-type disc recording equipment. Form *2J-6895* can be obtained from Department 522, RCA Engineering Products, Camden 2, N. J.

Microcasting Case Histories. A folder describing precision casting applications, called a "File on Microcasting Case Histories," has been published by the Microcast Division of Austenal Laboratories, Inc., 715 East 69th Place, Chicago 37, Ill. It is available upon request.

Life-Line Motors and Generators. Booklet *B-4595*, containing information on the new life-line type *SK* d-c motors and generators, is available from the Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

Electrometer. The Loudon model *361-* dynamic condenser electrometer has bee described in a booklet released by Loudo Instruments, Inc., 5644 Lake Park Avenue Chicago 37, Ill. Designed especially fo nuclear research work, this electromete has measuring ranges and operating flexibility suitable for general laborator measurement of small direct currents an voltages in high resistance circuits. Th booklet may be obtained upon request.

GIANT OKONITE SUBMARINE CABLES BRING MORE POWER TO PORTLAND



Over 55 tons of 5-inch Okonite cable . . . laid across the Willamette River by Portland General Electric Company in just 40 minutes! Okonite reels were specially designed to expedite the job.

Two 13 Kv Okonite submarine cables were recently laid simultaneously across the Willamette River, Portland, Oregon in 40 minutes. This notable engineering feat represents a vital transmission link between a power plant on the east side of the city with the underground system in the west side business district.

Measuring 5 inches in diameter and weighing 31 pounds per foot, these 1800-foot rubber insulated cables were protected by steel armor wire. Special Okonite-designed reels helped to speed the laying.

Of particular interest in the engineering of these cables was the high voltage testing used to check out any tiny hidden defects which would not show up under ordinarily-specified test voltages. Designed for operation at 13,000 volts, these cables were tested at 93,000 volts for 15 minutes at d-c during fabrication. After armoring they were tested at 75,000 volts for the same period at d-c — in addition to a-c high voltage tests.

The 500,000 CM conductors in these cables were insulated by the famous Okonite strip process, assuring absolute uniformity of wall thickness . . . perfectly centered conductors. As in other Okonite cables, the insulated conductors were vulcanized in a continuous metal mold under high pressure, resulting in higher density, greater physical and electrical uniformity.

No matter what Okonite cable you buy, you can be sure of obtaining true cable economy . . . the economy of long life and uninterrupted service. The Okonite Company, Passaic, N. J.

THE BEST CABLE IS YOUR BEST POLICY

OKONITE SINCE 1878 *insulated wires and cables*

TOTALLY ENCLOSED 22 K

Supplant Conventional Open Designs on Duquesne Light Company Systems

Duquesne Light Company for many years urged the development of an arc-free air switch that could be metal-clad, yet capable of interrupting load and charging currents at 22 KV.

Such a switch was needed for their 22 KV loop and double tap systems to permit the total enclosure of unit substations, successive steps towards which had been taken in recent years, as pictured here, by enclosing the secondary switchgear and by placing underground the secondary, then the primary connections. All that remained exposed was the primary switchgear.

Following the S&C development of 23- and 34.5-KV interrupter switches, the metal-clad switchgear unit shown on the right was designed jointly by Duquesne Light Company and S&C. The result is the totally-enclosed 2000 KVA unit substations shown below, on which they comment:

> **"It was found . . . because of the proximity of various hazards, small sites, and safety against external interference . . . that the totally enclosed job permits a satisfactory and safe installation that might have to be located elsewhere if these features had not been developed. In fact, the totally enclosed job will be used in all future installations with few, if any, exceptions."**

S&C Metal-Enclosed Switchgear, using Alduti Interrupter Switches and Type SM Power Fuses, probably offers many advantages for your system also, including low original and maintenance costs. Your inquiry is invited.

The details of Duquesne Light Company's unit substation program are presented in a paper entitled "The Application of Unit Substations" by W. P. Holben and G. N. Hoffman. Copies will be sent on request.

1950

22 KV and 4 KV Underground; switchgear totally enclosed

S&C ELECTRIC

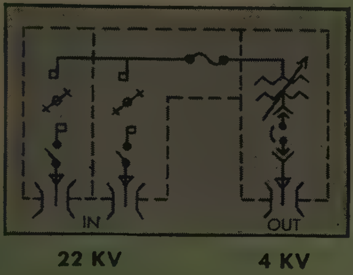
Formerly SCHWEITZER & CONRAD, IN

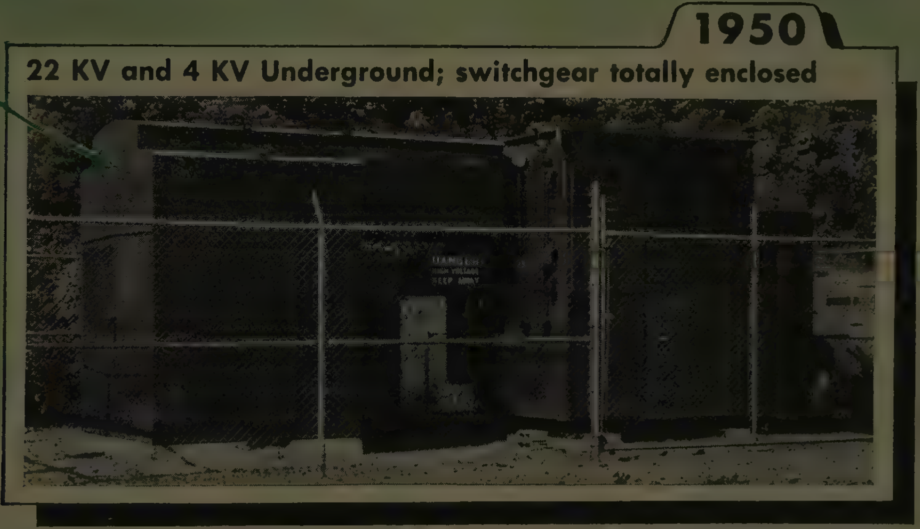
UBSTATIONS

22 KV and 4 KV Overhead 1947

22 KV Overhead, 4 KV Underground 1948

22 KV and 4 KV Underground 1949





1950

22 KV and 4 KV Underground; switchgear totally enclosed

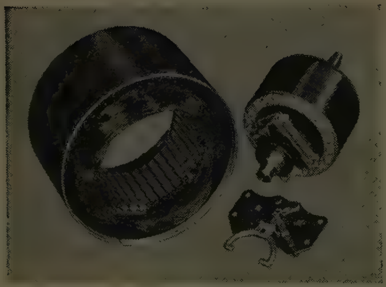
COMPANY

4427 Ravenswood Avenue
Chicago 40, Illinois, U. S. A.

In Canada, Powerlite Devices, Limited, Toronto

Want to dunk a motor without drowning it?

JACK & HEINTZ does it!



J & H Precision-built rotor, stator and switch are designed to operate immersed in oil and to fit customer's housing and pump.

No need to bring us blueprints . . . J & H creative engineers design *Rotomotive* equipment for many industries. They develop, test and produce working models. They are the reason why J & H custom-built motors can solve special problems.

By immersing this motor in oil, one-third more power is developed, and the capacity of our customer's specially designed pump gains a sizable competitive lead.

Since oil is unfriendly to motors, this motor has unusual features—like oil-resistant insulation and special, corrosion-resistant switch contacts. We furnish stators, rotors and switches which must fit perfectly with parts made by our customer to insure both a hermetic seal and dependable performance.

The engineering and production problems involved here are typical of those J & H tackles every day. Whether you want a complete motor or parts to fit your own product, whether unusual design or unusual operating conditions are involved, whether your quantities are large or small—just remember that Jack & Heintz *does it!*

For information, write Jack & Heintz . . . Cleveland 1, Ohio.

JACK & HEINTZ
Rotomotive
EQUIPMENT

means electrical, hydraulic or mechanical devices designed to solve unusual problems of developing power, controlling it, or using it

DON'T GUESS ABOUT WIRING!

THE NEW SPRAGUE

Adequate Wiring Analyzer

- This handy, portable instrument makes it quick, simple and easy to check existing wiring to see if it will safely carry proposed loads or if it is adequate for present loads. An effective visual on-the-job convincer to show customers the effect on adequacy of wiring as loads grow.
- Meter pointer indicates percent voltage drop under load directly on 115 or 230 volt circuits. No calculations to confuse customers!
- Furnished complete with connectors for convenience outlets, electric ranges, panel boards, etc., for industrial, home, farm, and shop use.

Write for Bulletin PF-600

THE NEW SPRAGUE

Interference Locator

Find POWER LINE RADIO NOISE SOURCES *Quickly!*

- The ideal, portable instrument for fast, easy location of radio noise sources on power lines and electrical equipment.
- Compact, rugged, easy to operate.
- Utilizes 8-tube superheterodyne circuit. Frequency range from 550 kc to 30 mc.
- Operates from self-contained dry batteries, automobile battery, or 115 volt lines.
- Features include loop and collapsible rod antennas, built-in loudspeaker, built-in dual range output and battery test meter, calibrated r-f and audio gain controls, and beat frequency oscillator.

Write for Bulletin PF-601

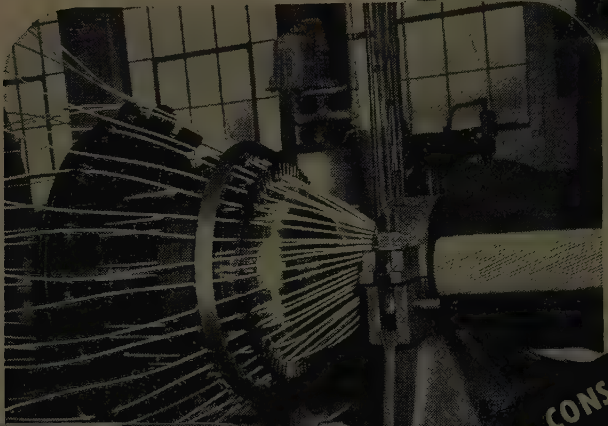
SPRAGUE®

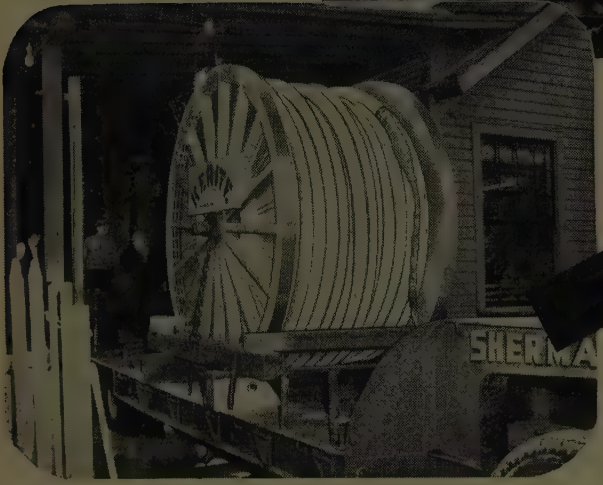
PIONEERS IN ELECTRIC AND ELECTRONIC DEVELOPMENT

SPRAGUE ELECTRIC COMPANY
NORTH ADAMS, MASSACHUSETTS

way protection

insures the long-life inherent in Kerite Cable





Kerite's 3-way protection of *quality*—through the finest possible engineering, workmanship, and handling—insures you a 3-way service benefit—the safety, reliability, and economy that are inherent in the insulation itself.

Whether it's a special cable or one for the standardized circuits of power-plant and signaling operation, Kerite welcomes the opportunity to consider your requirements in the light of nearly a century's experience applying the exclusive Kerite formula to vital cable services.

THE KERITE COMPANY, 30 Church Street, New York 7, N. Y. Offices also at 122 Michigan Avenue, Chicago; 582 Market Street, San Francisco; 3901 San Fernando Road, Glendale 4, Calif.

DAYS KERITE

KERITE CABLE

Kerite Insulation—Your Cable's Best Life Insurance

Sh-h-h!

DON'T SPREAD IT AROUND . . . . .

We're in full-scale production in our new, larger plant.

(Our previous factory was destroyed by fire on January 10, 1951.)

With our expanded facilities, we can promise you good delivery on Glassmikes, Plasticon Capacitors, HiVolt Power Supplies and Pulse Forming Networks . . . if you promise to give us realistic delivery requirements.

MANUFACTURERS
Glassmike Capacitors
Plasticon Capacitors
HiVolt Power Supplies
Pulse Forming Networks

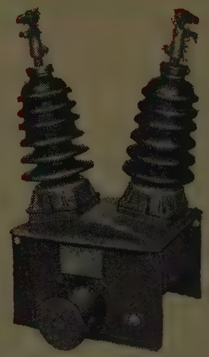
All Phones. **AMbassador 2-3727**

Condenser Products Company

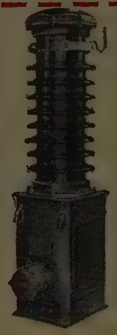
[illegible] North Clark Street • Chicago [illegible], Illinois

HIGH-VOLTAGE OIL-FILLED
Instrument Transformers

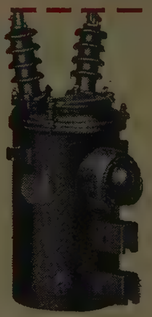
TYPE KC-356
Current Transformer
230,000 volts



TYPE E-236
Potential Transformer 24,000:120 V.



TYPE KG-9
Current Transformer 69,000 V.



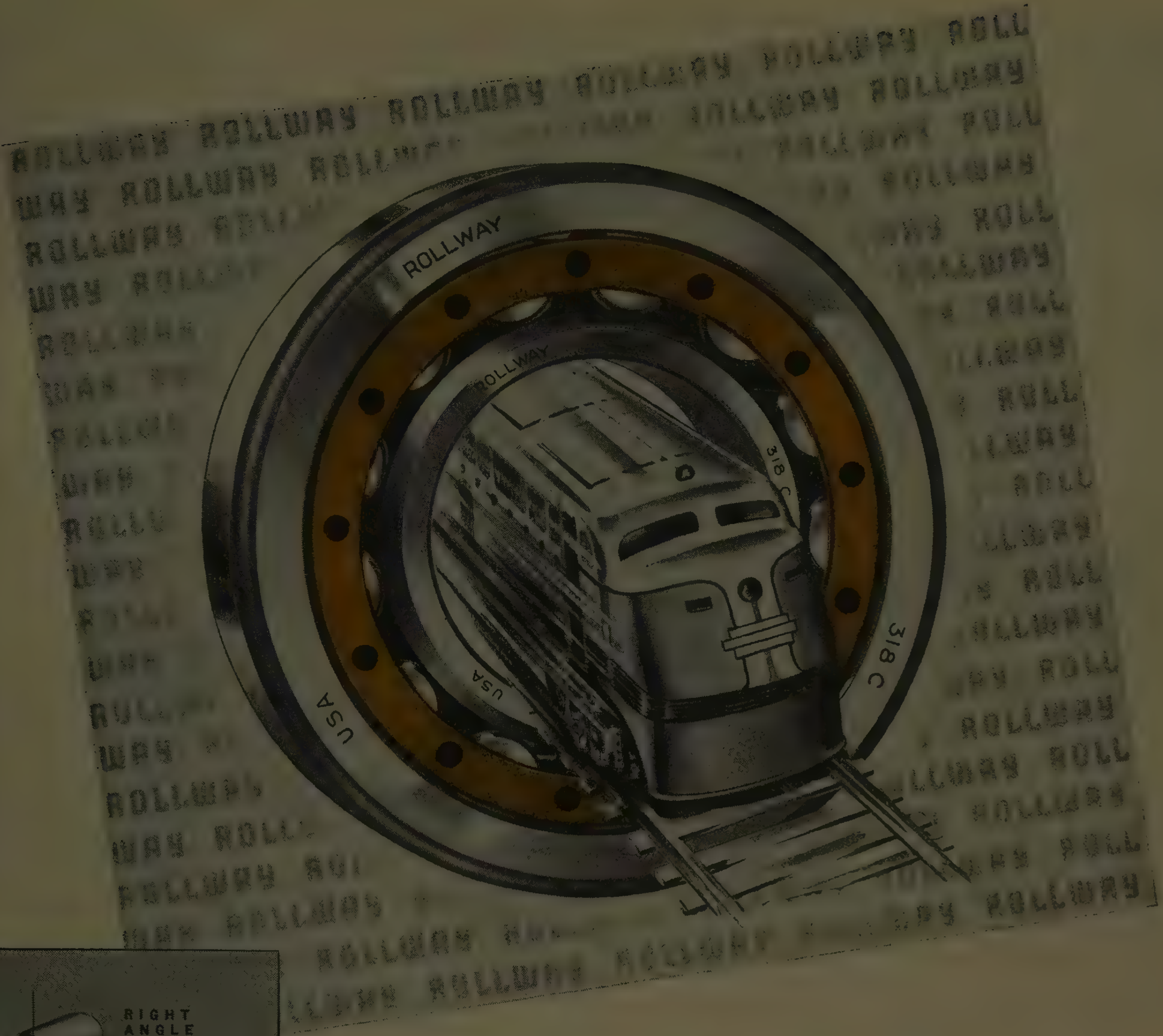
TYPE ET-5
Potential Transformer 14,400:120 V.

TYPE ET-12
Potential Transformer 138,000:115 volts

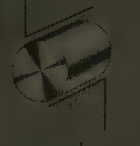
FOR HIGH-VOLTAGE APPLICATIONS UP TO 287 KV, General Electric offers a complete line of oil-filled instrument transformers. A representative group is shown above. These transformers are available for all types of applications. For further information, contact your G-E representative or write for the new 1951 Instrument Transformer Buyer's Guide, (GEA-4626), Section 604-28, General Electric Company, Schenectady 5, New York.

504-28

GENERAL ELECTRIC



RIGHT ANGLE Roller Ends, precisely square to avoid end-rub, oscillation and side-shock.



RIGHT ANGLE Bearing Surfaces—parallelism that promotes unwavering rightline rolling.

RIGHT ANGLE Separator Slots, accurately machined to prevent skew, slide and uneven wear.

For Pinion and Commutator Ends of Traction Motors

In the most demanding types of service Rollway Bearings ROLL RIGHT because they're MADE RIGHT. Under load, there's no skew of the rollers —no dragging end-rub or destructive side shock. True right-angle alignment results in longer bearing life during continuous heavy-duty operation . . . cuts maintenance cost and lay-up time.

Roll the RIGHT WAY with ROLLWAY! Send us your bearing problem. Our engineers will gladly make necessary calculations, drawings and supply the information required for its solution. No charge or obligation.

ROLLWAY BEARINGS

Complete Line of Radial and Thrust Cylindrical Roller Bearings

Rollway Bearing Co., Inc.
Syracuse, N. Y.

SALES OFFICES

Philadelphia
Cleveland
Houston
Pittsburgh
Chicago
Boston
Detroit
Los Angeles

QUIET as a Champion's Caddy!

HERE'S WHY:

① Pinco "NOCORONA" Units have "fired-in" radio proofing . . . physically and ceramically an integral part of the insulator.

② Have smooth conductor surfaces; are free from "fringe effect" and are resistant to arc-over burns.

③ Have rugged construction, unaffected by "NOCORONA" treatment.

④ Have service records dating back to 1929 *proving* quietness at operating voltage.

⑤ Have been manufactured since 1929 by approved Pinco processes.

See Page 38, Pinco Catalog No. 49
for complete electrical and mechanical characteristics.

The Porcelain Insulator Corporation
763 Main St., Lima, N. Y.
[illegible]
[illegible]

PINCO
INSULATORS

Suspension Insulators . . . Switch and Bus Insulators . . . Distribution Clamps . . . Distribution Pin Types and Guy Strains . . . Transmission Line Fittings . . . Tree Insulators . . . Transformer and Circuit Breaker Bushings . . . One Piece and Multi-part High Voltage Pin Types . . . Suspension and Strain Clamps . . . Indoor Bus Support Porcelain . . . Lightning Arrester Porcelain.

Where the Requirements are Extreme . . .

Use
SILVER
GRAPHALLOY*

For extraordinary electrical performance

GRAPHALLOY
TRADE MARK REG. U. S. PAT. OFF.

THE SUPREME BRUSH AND CONTACT MATERIAL

IN BRUSHES

- for high current density
- minimum wear
- low contact drop
- low electrical noise
- self-lubrication

IN CONTACTS

- for low resistance
- non-welding character

*Graphalloy is a special silver-impregnated graphite

Accumulated design experience counts—call on us!

GRAPHITE METALLIZING CORPORATION
1053 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

Hummingbirds that boss Eagles . . .

In the realm of the airman, where tiny high-precision motors regulate intricate systems of instrumentation and control, Kollsman miniature motors have no peer.

In fact, these accurate and dependable units have been a Kollsman specialty for years.

Yes, throughout aviation history—where hummingbirds have had to boss eagles—Kollsman has won renown for doing the job inimitably well.

for precision and dependability
look to **KOLLSMAN**
INSTRUMENT CORPORATION
Elmhurst, New York • Glendale, California

the spike test proves it!

PS Shielding*

American PS Shielded Cables are perfect for aerial lines. Tree trimming is practically eliminated. Corona troubles vanish . . . along with television and radio interference.

Here's a good example of the way PS Shielding prevents corona formation. The conductor on the left is insulated with unshielded "ozone-proof" rubber. But the PS Shielded Cable on the right is completely free from corona.

PS Shielding is so flexible, light and small that it is easy to manhandle over support rigs in the most rugged country.

PS Shielding provides an extra margin of safety when cable must be dragged over sharp rock and when it must be handled by workers.

UNITED STATES STEEL

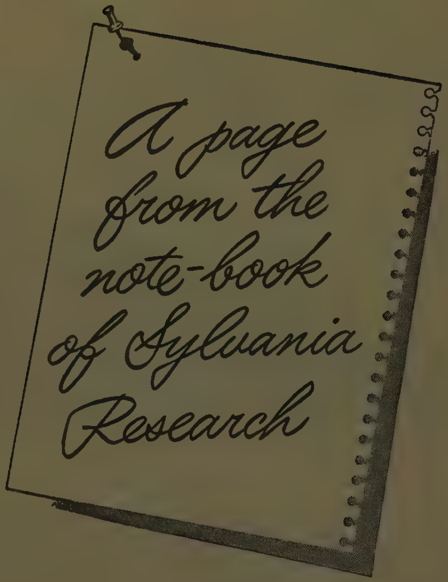
LOWER TOLERANCE · HIGHER PROTECTION

Every lightning arrester is rated for operating tolerance. This is *added to* average published values. More important, however, *it is deducted from the arrester's protective function!* The lower the tolerance, the higher the protection--the more safety you get from your arrester investment. . . O-B Thorex lightning arresters have brought a radically low tolerance range to the American power industry, in terms of less than + 10 per cent sparkover and less than + 5 per cent IR discharge voltages. . . On older apparatus this added protection may be vital, since insulation levels can be considerably below new, modern standards. On more recent equipment, the added protection made possible with the O-B Thorex, is welcome insurance for costly station investments. . . Investigate the improved operating standards made possible by the advanced protective characteristics of Thorex arresters.

Ohio Brass

MANSFIELD · OHIO

4129-H


A page from the note-book of Sylvania Research

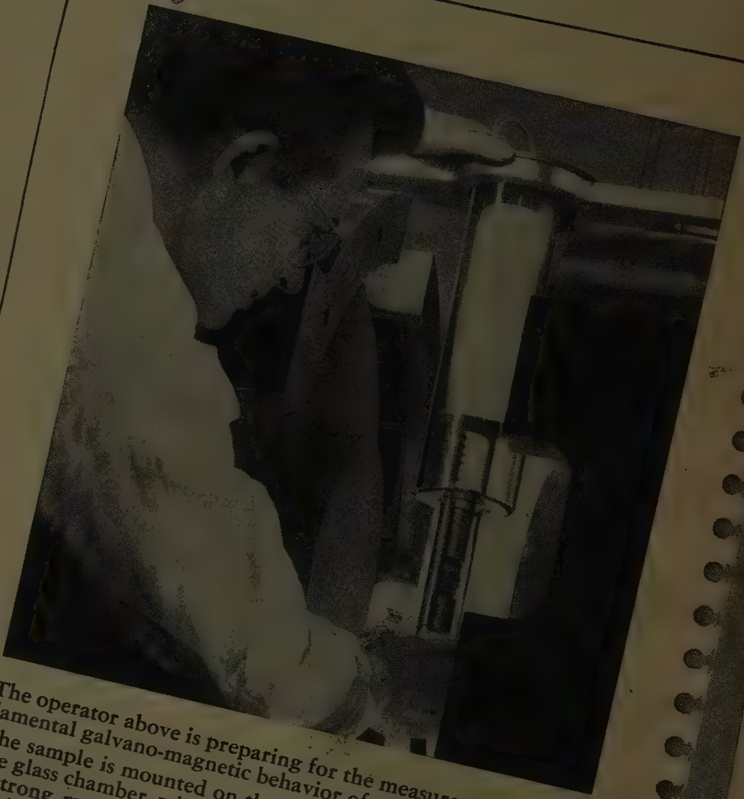
Sylvania research in semiconductors leads to development of new Germanium Photodiode

The new Sylvania Germanium Photodiode, the tiniest photosensitive device ever manufactured, is another example of the dividends of Sylvania's broad program of basic research.

Basic research on semiconductors, one important phase of this program, has promoted a better understanding of the mechanism of current flow in semiconductor materials. The new 1N77 Photodiode, for example, is a result of studies of the variation in resistance of germanium caused by radiant energy.

It will make possible, for the first time, very small size automatic multiple counting, inspecting and recording systems.

Other research in this field has contributed to the improvement of germanium and silicon crystal diodes which are now widely used in television sets, electronic computers and military radar equipment.



The operator above is preparing for the measurement of fundamental galvano-magnetic behavior of a germanium crystal. The sample is mounted on the small insulating block within the glass chamber, which may be evacuated. The influence of a strong magnetic field upon the current path through the semiconductive germanium may be determined by placing electrodes at suitable points on the surface of the crystal. The temperature of the crystal may be varied from +600°C, to −195°C.

SYLVANIA ELECTRIC

ELECTRONIC DEVICES; RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SET

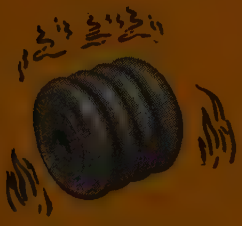
NOW Another Use For GLASTIC

KEYSTONE
GLASTIC
INSULATORS

Exceptional resistance to impact and vibration.

Excellent arc-tracking resistance.

Non-absorbent. Resists chemicals, most acids, salts and hydrocarbons.


Suitable for operation under maximum sustained temperatures up to 300° F.

A KEYSTONE EXCLUSIVE...

OFFERS NEW APPLICATION POSSIBILITIES!

Insulators made of Glastic . . . with superior physical and dielectric properties. Keystone Glastic insulators offer you advantages not obtained with insulators made of phenolics. Glastic has exceptional resistance to impact and vibration. Resists high heat, chemicals, extreme weather conditions. Has excellent arc-tracking resistance and is non-absorbent.

Keystone Glastic insulators provide you with outstanding application possibilities. Withstand severe operating conditions . . . stand up where ordinary insulators fail.

Design engineers will find Keystone Glastic insulators highly adaptable for application on new installations, or in modernization. Electric Service engineers are ready to work with you on any insulator problem . . . to make insulators of Glastic to your exact design requirements.

Find out more about this amazing insulator today. Write for the new folder that describes the Keystone Glastic insulator in detail. Ask about other Keystone products for Industry, including collectors, cable strain clamps and contact rail shoes.

ELECTRIC SERVICE MANUFACTURING CO.
PHILADELPHIA 32, PENNA

OHMITE JAN-TYPE WIRE-WOUND RESISTORS

MEET REQUIREMENTS OF JOINT ARMY-NAVY SPECIFICATION JAN-R-26A

STYLES AND SIZES

TAB-TERMINAL TYPE

†Characteristics G and J

Style	Overall length	Diameter	*Watts
RW-29	1-3/4"	1/2"	8
RW-30	1"	19/32"	8
RW-31	1-1/2"	19/32"	10
RW-32	2"	19/32"	12
RW-33	3"	19/32"	18
RW-34	3"	29/32"	30

Style	Overall length	Diameter	*Watts
RW-35	4"	29/32"	38
RW-36	4"	1-5/16"	60
RW-37	6"	1-5/16"	78
RW-38	8"	1-5/16"	110
RW-39	12"	1-5/16"	166

TAB-TERMINAL TYPE with terminal hole to clear No. 8 screw

†Characteristics G and J

Style	Overall length	Diameter	*Watts
RW-40	3"	29/32"	24
RW-41	4"	29/32"	32
RW-42	4"	1-5/16"	49
RW-43	6"	1-5/16"	74
RW-44	8"	1-5/16"	100
RW-45	12"	1-5/16"	160
RW-46	10-1/2"	1-5/16"	135
RW-47	10-1/2"	1-9/16"	145

FERRULE-TERMINAL TYPE

†Characteristics G and J

Style	Overall length	Diameter	*Watts
RW-10	11-7/16"	1-5/16"	140
RW-11	9-5/8"	1-5/16"	116
RW-12	7-7/16"	1-5/16"	86
RW-13	5-1/8"	1-1/16"	50
RW-14	4-7/16"	1-1/16"	40
RW-15	2-15/16"	3/4"	20
RW-16	2-3/8"	3/4"	14

FLAT (Stack Mounting) TAB-TERMINAL TYPE

Characteristics G and J

Style	Overall length	Width of Core	Thickness of Core	*Watts
RW-20	2-1/2"	1-3/16"	1/4"	15
RW-21	3-1/4"	1-3/16"	1/4"	22
RW-22	4-3/4"	1-3/16"	1/4"	37
RW-23	6"	1-3/16"	1/4"	47
RW-24	7-1/4"	1-3/16"	1/4"	63

AXIAL-TERMINAL TYPE

Characteristics G and J

Style	Length of Core**	Diameter	*Watts
RW-55	1-3/8"	5/8"	5
RW-56	2"	5/8"	10

**2-1/2" wire leads

*Watts free air JAN Characteristic "G"

†Also meet requirements of Characteristics F, H, E, and D which were recently removed from Spec. JAN-R-26A. (Amend. 2)

Ohmite offers an unusually complete line of resistors that meet the most rigid requirements (Characteristics "G" and "J") of Joint Army-Navy Specification JAN-R-26A. To meet these requirements, resistors must pass severe moisture resistance and thermal shock tests. They are required to withstand strenuous vibration applied for five continuous hours. And, they must satisfy the requirements of many other tests, including momentary overload, mechanical strength, and terminal strength.

Of the 38 different resistor styles listed in JAN-R-26A, Ohmite offers 33 styles that meet these specifications. These styles represent the most popular resistors, and are available in a complete range of resistance values, in the types and sizes listed.

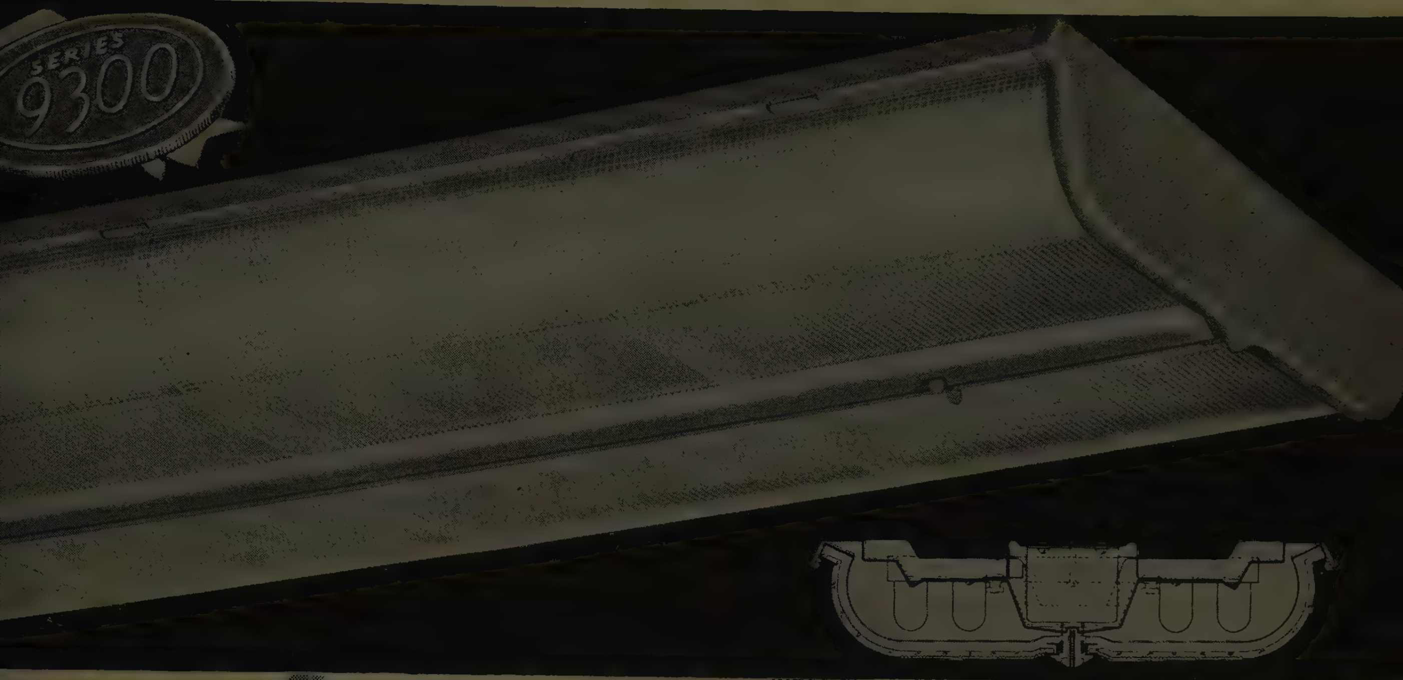
OHMITE MANUFACTURING COMPANY
4803 Flournoy St., Chicago 44, Ill.

Be Right with...

OHMITE

RHEOSTATS • RESISTORS • TAP SWITCHES

's HERE! NEW HOLOPHANE Lighting Series..Introducing HIGH EFFICIENCY with MAXIMUM VISUAL COMFORT



Low Brightness

High Output

Easy Installation

Dramatic New Styling

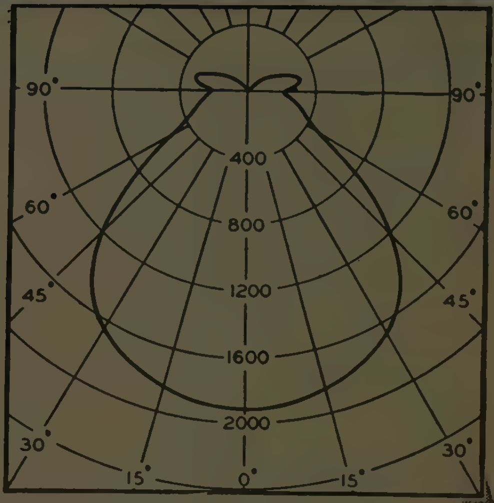
Continuous Installation

Bipin or Single Pin

Minimum Depreciation

Streamlined Styling

The shallow depth of the 9300 Series simulates the modern overall appearance of recessed units without the expense of roughing-in...



The newest, important Holophane contribution to lighting advancement is the 9300 Series of Surface-Attached HOLOFLUX* Units, result of long research and development . . . Their enclosed prismatic construction assures the greatest light output for fluorescent lamps with complete absence of cumulative glare, even in long, continuous runs . . . Because HOLOFLUX Units are applicable to such a wide variety of lamp arrangements, the best level of illumination is attainable for any specific interior. The prismatic glass panels are not subject to permanent depreciation; are easy to keep clean . . . The 9300 Series is recommended for commercial and institutional buildings . . . offices, classrooms, drafting rooms, stores, schools, banks and libraries. Architects and engineers are invited to submit plans for lighting recommendations by Holophane engineers.

Write for New 9300 Series Folder today.

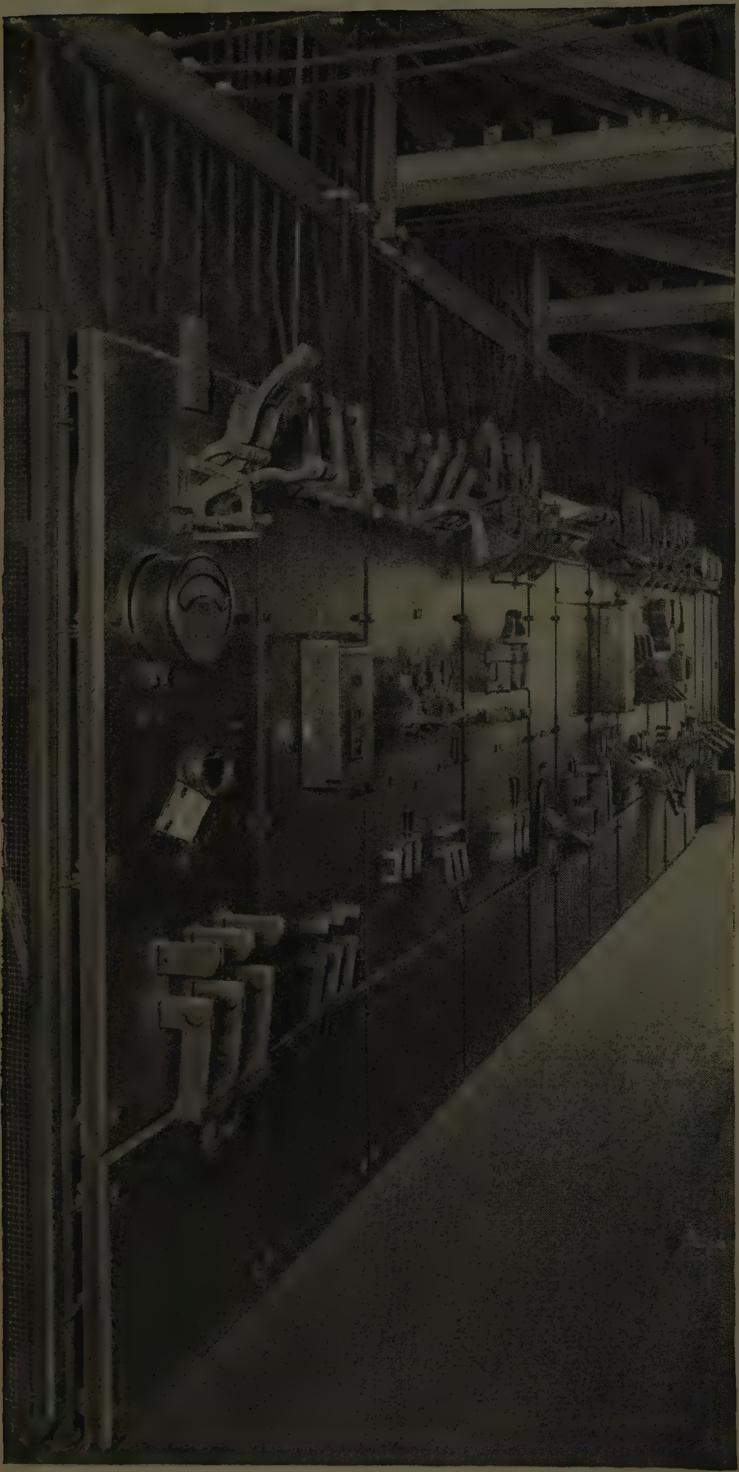
HOLOPHANE COMPANY, Inc.

Lighting Authorities Since 1898 • 342 MADISON AVENUE NEW YORK 17 N.Y.
THE HOLOPHANE COMPANY, LTD., THE QUEENSWAY, TORONTO 14, ONTARIO

g. U.S. Pat. Off.

Power bottleneck broken

New G-E Metal-Clad switchgear provides for increased output, gives greater safety



This is the old open-type switchgear originally installed at the Traylor Engineering & Manufacturing Co. Exposed switches were a safety hazard. With extra feeders added through the years to take care of expansion, the rear of the switchboard had become a tangle of cables, inviting short circuits. Old 240-volt distribution system seriously limited future expansion.

Old equipment was inadequate for growing needs

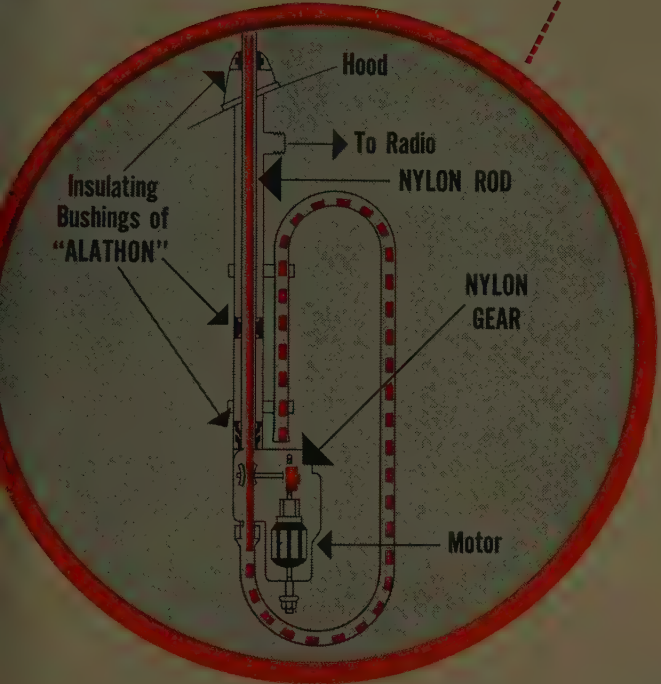
After years of service at the Traylor Engineering & Manufacturing Co., Allentown, Pa., the old-fashioned switchgear shown at left was operating on borrowed time. Already over-loaded through increasing power demands, it had become a bottleneck that limited expansion and hampered efficient production.

With interrupting devices entirely inadequate to handle the power that could be delivered under short-circuit conditions, any major fault in the system could have been disastrous.

Today this obsolete equipment has been replaced by modern G-E metal-clad switchgear. Dangerous exposed switches have vanished. Interrupting capacity is adequate to take care of abnormal conditions. And a modern high-voltage distribution system assures ample power for years to come. See opposite page.

For information on similar equipment for your plant, contact your G-E sales representative—or write for Bulletins GEA-3083 Metal-clad Switchgear; GEA-3592 Load-center Unit Substations; GEA-3758 Load-center Power Distribution. *General Electric Company, Schenectady 5, N. Y.*

New Packard antenna design employs two Du Pont plastics



When driver pushes button, motor-driven worm gear turns nylon gears, which turn spring-loaded pulleys. Nylon rod is driven up by pulleys, forcing "live" members upward. Rod coils into trombone-like shape (dotted line) when antenna is lowered. (*Automatic antenna used on 1951 Packards made by Casco Products Corp., Bridgeport, Conn.*)

Nylon plastic and "Alathon" polythene resin meet mechanical and electrical requirements for automotive antenna

Two Du Pont plastics materials—nylon and "Alathon"* polythene resin—are playing key roles in the success of this new motor-driven antenna used on Packard automobiles. A 4½-foot flexible rod which raises and lowers the "live" members is made of nylon, as are the two gears that transmit power from the motor to pulleys which drive the rod upward and downward. Insulating bushings, which must have very low moisture-absorption and excellent dielectric properties at radio frequencies, are molded of "Alathon."

The rod must have an unusual combination of properties. Most important of these: it must be rigid enough to force the antenna up and down, yet flexible enough to fold into a trombone-like position when the antenna is down; and it must also have good dielectric properties. Only nylon was found to meet the mechanical requirements, while at the same time maintaining a high "Q" and low capacity. The nylon rod and gears have been subjected to as many as 80,000 cycles—many more times than they could possibly be called on to withstand during the life of any car. Neither shows any sign of wear.

Both nylon and "Alathon" are finding a number of uses in molded parts for electrical equipment, in addition to their many well-known applications in wire and cable. Nylon is used in such items as coil forms, insulator bushings, grommets, motor slot liners, switch components . . . "Alathon" in radio and television parts, potting compounds, etc.

Demand for both nylon and "Alathon" currently exceeds supply. However, we suggest that you evaluate these materials for future application. We will gladly discuss the availability of quantities for development work. For additional information, write:

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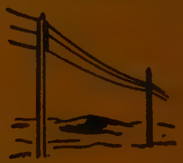

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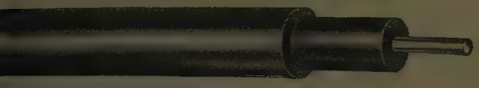

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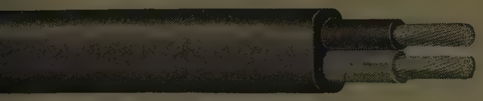

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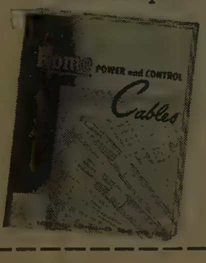

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For long, economical service life RoMarine-RoPrene gives you *double protection* against costly circuit failures. RoMarine insulation affords high resistance to heat and moisture. The RoPrene (Neoprene) sheath has excellent resistance to oils, acids, alkalies, corrosive fumes, flame and abrasion. Its wide acceptance attests its popularity . . . hundreds of thousands of feet in service have proved its dependability.

RoMarine-RoPrene is less costly, easier to handle, tap and splice than lead sheathed cables. It is unaffected by electrolysis, extreme temperature changes and installed underground provides insurance against power outages from destructive storms. Its versatility reduces inventory.

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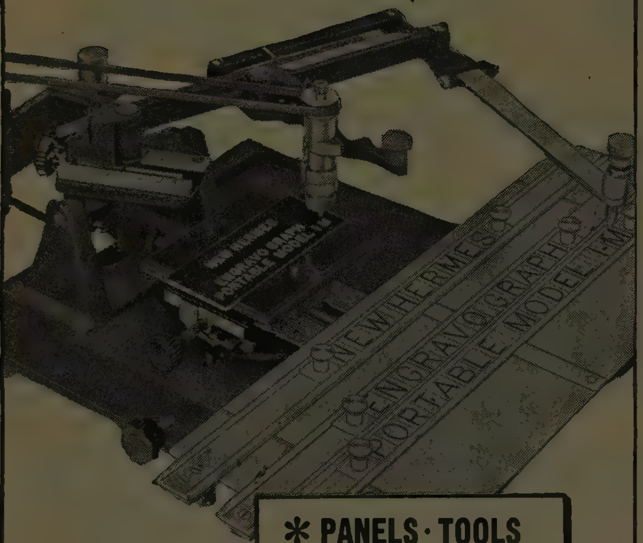

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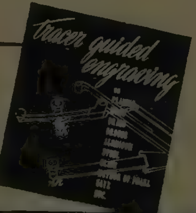

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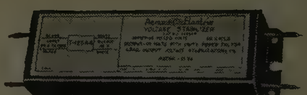
Provides for manual regulation of input voltage over a range from 65 to 135 volts to exactly the voltage required for best performance of the electrical equipment. Available in sizes from 150 watts to 10 KVA.



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This is an example of what Acme Engineers have done in designing transformers with secondary output up to 10,000 volts. High voltage can be safe when components are designed by experienced engineers.

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Custom-made transformers designed from standard parts is usually possible because Acme Electric owns all the tools, dies and equipment that are needed to make a wide variety of transformer designs and sizes. By adapting standard components available, you save time — money.

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Heavy duty designs in capacities from 1/10 KVA to 167 KVA in primary voltage input up to 2400 volts, can be supplied on special order with secondary taps to meet specifications of special applications.

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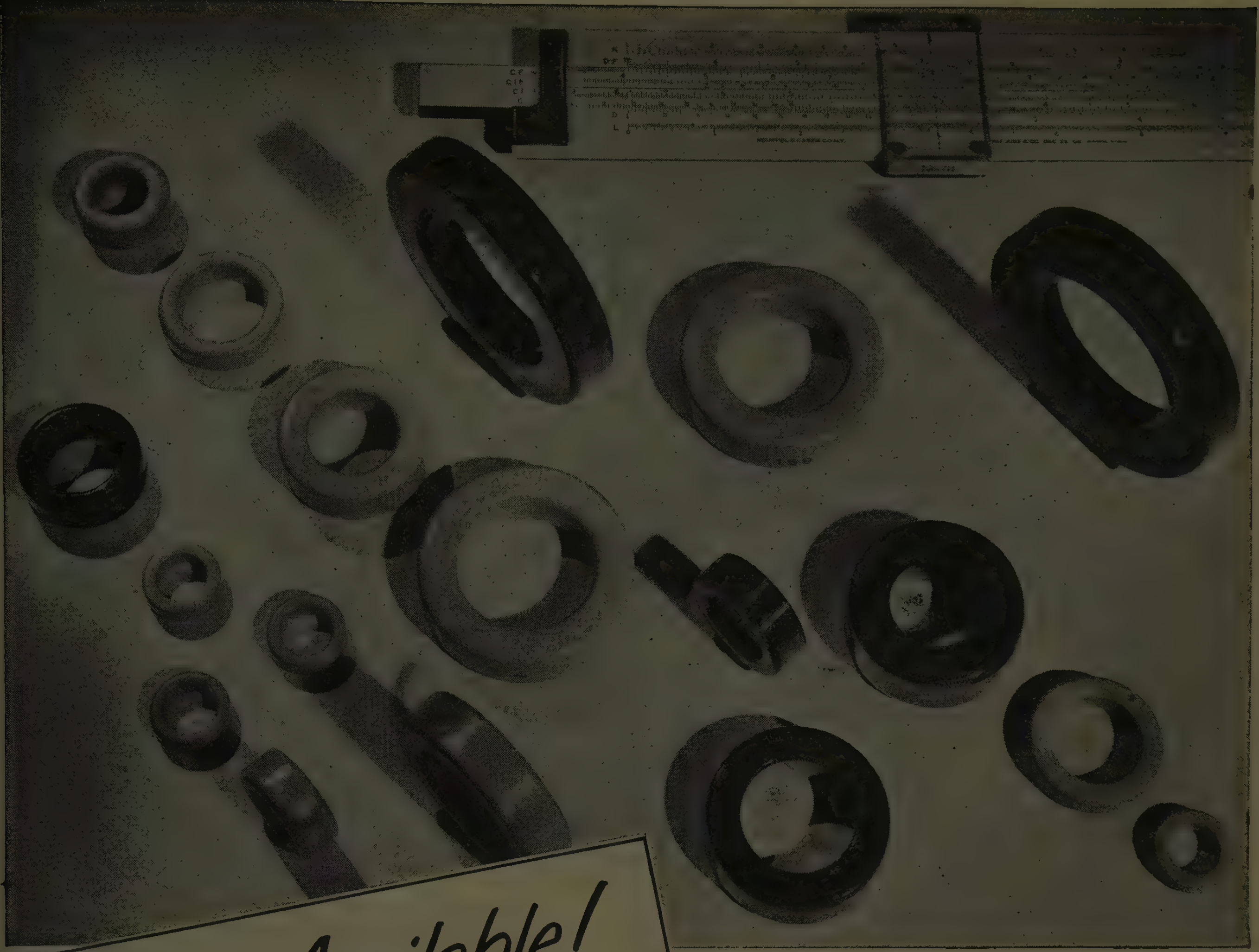
Acme ACME Electric
TRANSFORMERS



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MOLYBDENUM PERMALLOY POWDER CORES*

HIGH Q TOROIDS for use in Loading Coils, Filters, Broadband Carrier Systems and Networks—for frequencies up to 200 KC

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- ★ Available in a wide range of sizes to obtain nominal inductances as high as 281 mh/1000 turns.
- ★ These toroidal cores are given various types of enamel and varnish finishes, some of which permit winding with heavy Formex insulated wire without supplementary insulation over the core.

For high Q in a small volume, characterized by low eddy current and hysteresis losses, ARNOLD Moly Permalloy Powder Toroidal Cores are commercially available to meet high standards of physical and electrical requirements. They provide constant permeability over a wide range of flux density. The 125 Mu cores are recommended for use up to 15 kc, 60 Mu at 10 to 50 kc, 26 Mu at 30 to 75 kc, and 14 Mu at 50 to 200 kc. Many of these cores may be furnished stabilized to provide constant permeability (±0.1%) over a specific temperature range.

** Manufactured under licensing arrangements with Western Electric Company.*

W&D 2930

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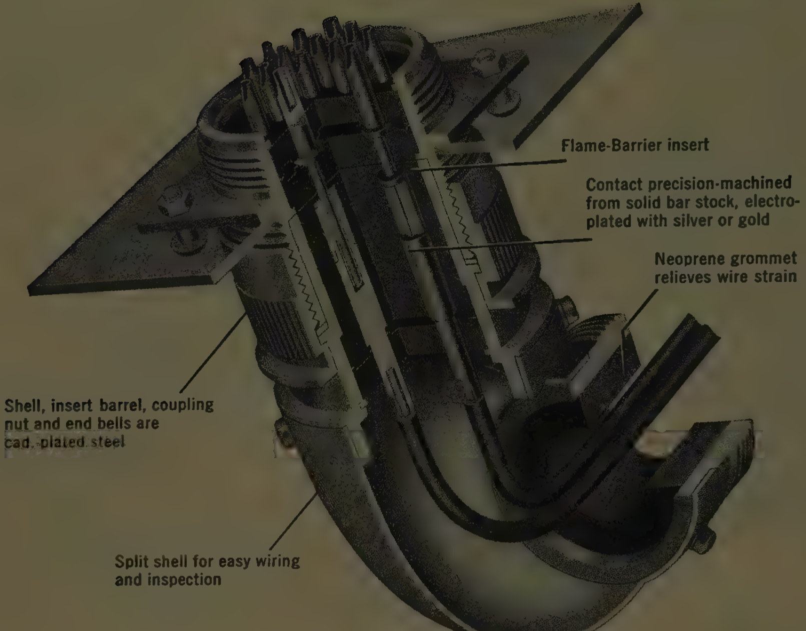
General Office & Plant: Marengo, Illinois

Here's why those in the know

—demand **CANNON PLUGS**


Flame-Barrier insert
Contact precision-machined from solid bar stock, electroplated with silver or gold
Neoprene grommet relieves wire strain
Shell, insert barrel, coupling nut and end bells are cad. plated steel
Split shell for easy wiring and inspection

Here is another example of the care Cannon Electric takes in developing a connector for specialized use. This is the Firewall Connector to prevent the spread of a possible aircraft engine fire through the bulkhead into wing sections.

Illustration shows Flame Barrier type with phenolic insert and contacts having solder cups. Shell must resist an open flame of 2000° F for 20 minutes. Electric circuits not required to remain active.

The Fireproof continuous service type is similar in appearance, but has crimp-on type contacts in fireproof insert material. Must carry rated DC current under open flame of 2000° F for five minutes and withstand vibration of ¼″ double amplitude at 2000 cycles per minute. Designed for aircraft, this connector has other applications where the going is tough. *For further information request Cannon Electric Firewall Bulletin.*

Cannon Electric AN Type Aircraft Firewall Connectors are available in 14 diameters with a large variety of insert arrangements in both Flame Barrier and Fireproof Types.

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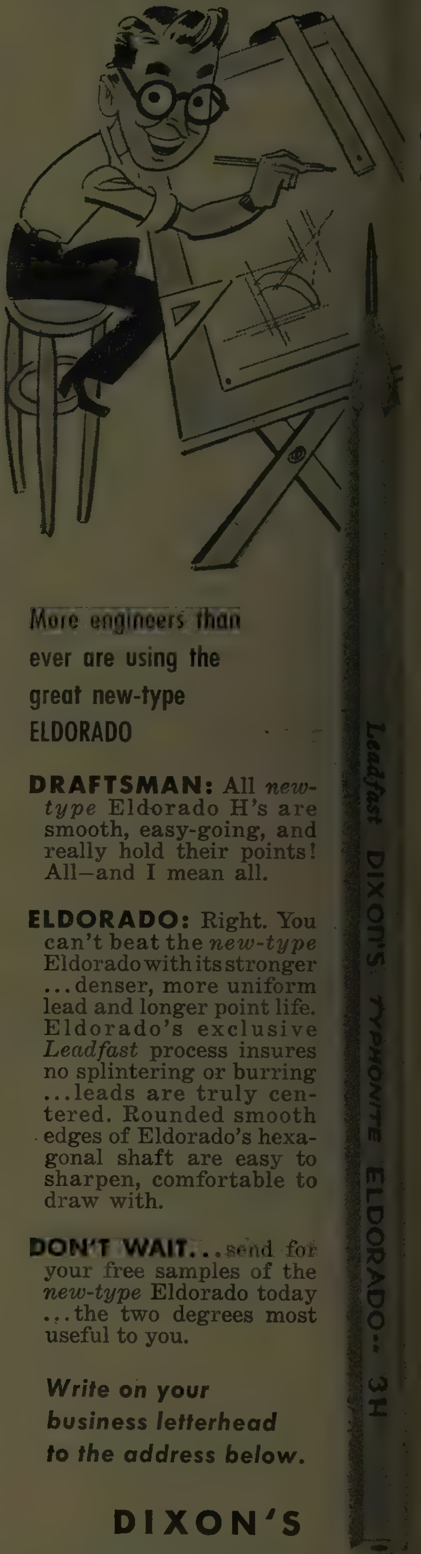
That New-Type ELDORADO Keeps Drawing Engineers!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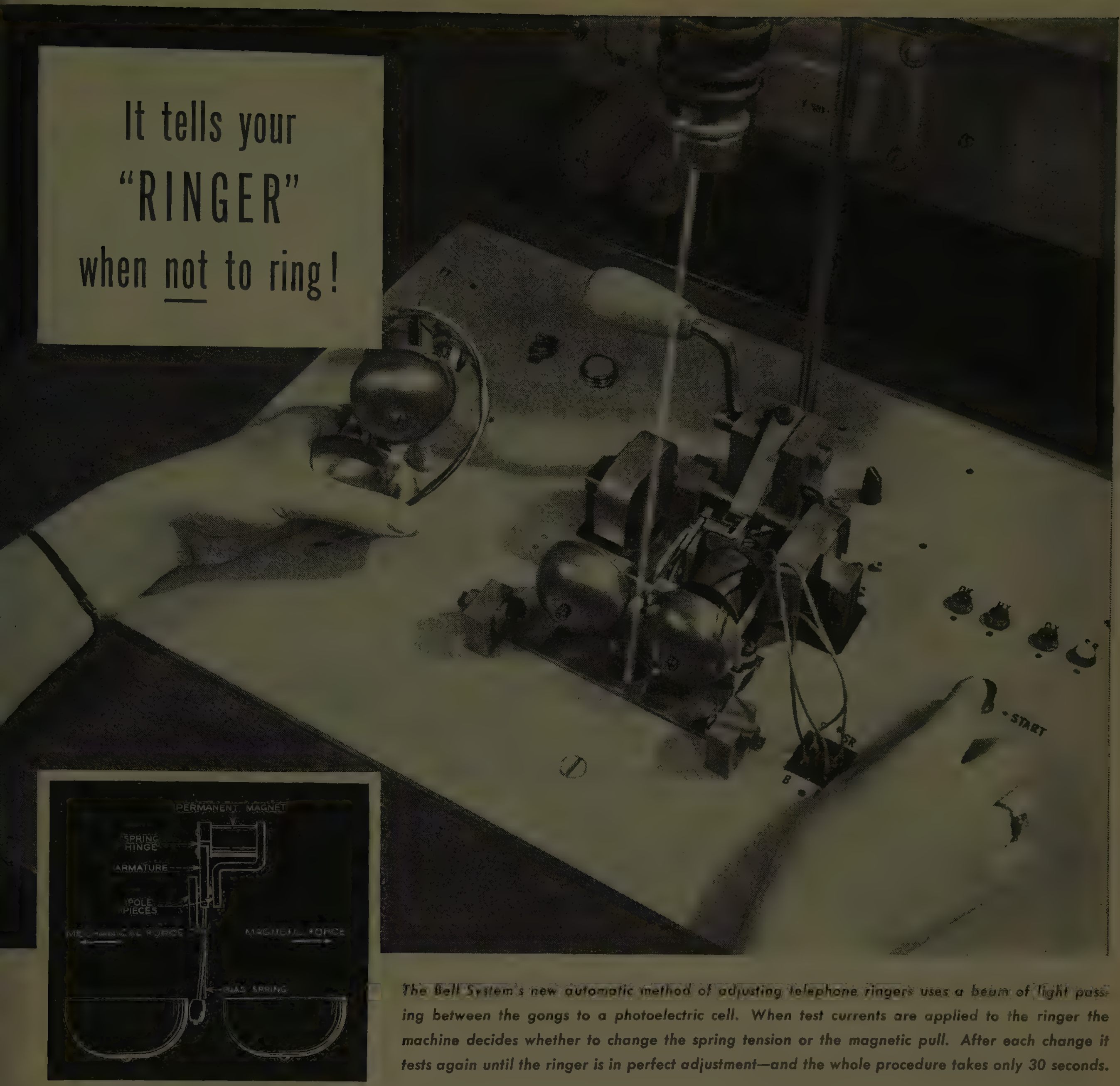
It tells your "RINGER" when not to ring!



The Bell System's new automatic method of adjusting telephone ringers uses a beam of light passing between the gongs to a photoelectric cell. When test currents are applied to the ringer the machine decides whether to change the spring tension or the magnetic pull. After each change it tests again until the ringer is in perfect adjustment—and the whole procedure takes only 30 seconds.

To YOU, it's your familiar telephone bell. To telephone engineers, it's a "ringer." And it has two jobs to do. It must ring, of course, when someone calls you. And it must overlook the numerous electrical impulses which do not concern it, such as those sent out by your dial.

Ability to respond to some impulses, to ignore others, requires exact adjustment between the pull of a magnet and the tension of a spring. If they are out of balance your telephone might tinkle when it oughtn't, or keep silent when it should ring.

In the past, adjustment was made by hand, little by little until the proper setting was reached. It took time. But now Bell Laboratories engineers have developed a machine which adjusts new ringers perfectly, before they leave the Western Electric Company plants where they are made. And the operation takes just 30 seconds.

This is another example of how the Laboratories work constantly to improve every phase of telephony — keeping the costs low while the quality of service grows higher and higher.

BELL TELEPHONE LABORATORIES

WORKING CONTINUALLY TO KEEP YOUR TELEPHONE SERVICE ONE OF TODAY'S GREATEST VALUES

IF YOU NEED

PORCELAIN INSULATORS

LIKE THIS

WE KNOW HOW TO MAKE THEM!

This insulator, with overall dimensions of 6¼ inches by 4⅞ inches by 2$\frac{13}{16}$ inches conceals under its smooth exterior, some difficult molding problems. As the photos show there is a $\frac{15}{16}$ inch skirt. Above this the body carries a rectangular, tapered socket, 2¾ inch deep, four post holes and two through holes. Long experience in solving such intricate design problems enabled Universal engineers to successfully reproduce this piece to extremely close tolerances with each piece of uniform density. A Universal engineer will be glad to work with you.

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shown above . . . and first introduced by Locke in 1920 as the worthy successor to the industry's first high voltage switch-type insulator . . . originated by Locke in 1911. Today No. 7785 is probably the best known of Locke's large family of Switch & Bus Insulators . . . every member of which you'll find is a masterpiece of engineering in its own right. Always specify them.

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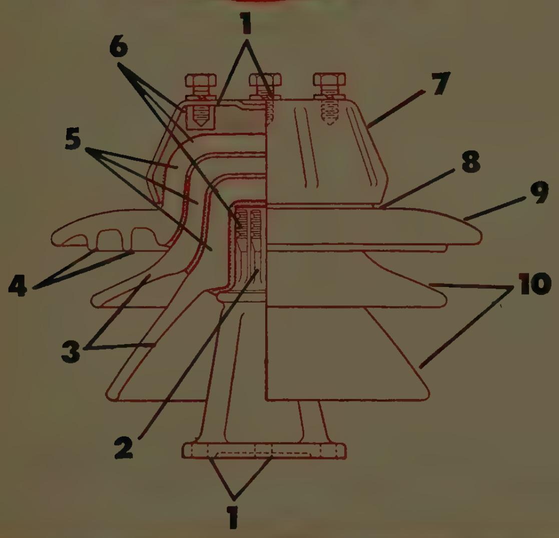
The LOCKE *high voltage* Switch Insulator



LOCKE DESIGN gives you ALL these advantages

1. Precision assembly jigs maintain positive alignment betwe tapped holes in the cap and bolt holes in the pin (or base). The t of the cap and bottom of the pin are parallel to within .015-inche Such accuracy means easy assembly of switches or other apparat mounted on them.

2. Vertical ribs on the inside of the caps and the outside of the pi provide high torsional strengths.

3. The Locke wet-process porcelain body—the toughest known— has been a standard of comparison since 1893. It is fully capable withstanding power arcs, lightning flashovers and extremely roug handling.

4. The contours of the corrugations are such as to give maximu resistance to mechanical impact consistent with total weight an balanced electrical characteristics. The depth of the corrugation assure full leakage distance.

5. Locke Compression Sand at the cement joints adds to strength and the stability of that strength, throughout the life of the insulator.

6. Non-hardening, resilient coatings, applied to all unsanded, load carrying surfaces, distribute loading efficiently and act as expansion joints under temperature changes. This contributes to longer life.

7. Galvanizing is done by the exclusive Locke Permazinc process— a quality-controlled, double hot-dip method that assures the highest degree of resistance to weathering and corrosion.

8. In assembly the lower edge of the cap is held positively away from the porcelain. This provides an expansion joint which prevents thermal changes from causing high internal stresses in the insulator.

9. Compression Glaze—a Locke development—assures high resistance to damage from thermal shock or mechanical impact. This means that Locke insulators can be handled faster in construction without danger of chipping or breaking.

10. The uniformly smooth glazed surface assures easy natural cleaning by wind and rain, and aids the insulator in maintaining its originally excellent electrical characteristics.

YOU ARE EQUALLY SURE of masterpieces of design when you specify other products in the complete line of Locke Insulators and Suspension Hardware. Each pays off in superior performance on transmission and distribution lines, generating stations, sub-station and electrical apparatus.

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OW VOLTAGE PIN TYPE INSULATORS

HIGH VOLTAGE PIN TYPE INSULATORS

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SWITCH & BUS INSULATORS

SPOOL INSULATORS

GUY INSULATORS

LIQUID-FILLED BUSHINGS

SUSPENSION & STRAIN CLAMPS

SUSPENSION HARDWARE

ENTRANCE BUSHIN

Instrument NEWS

Arco Cuts Testing Time 80% With Thickness Gage

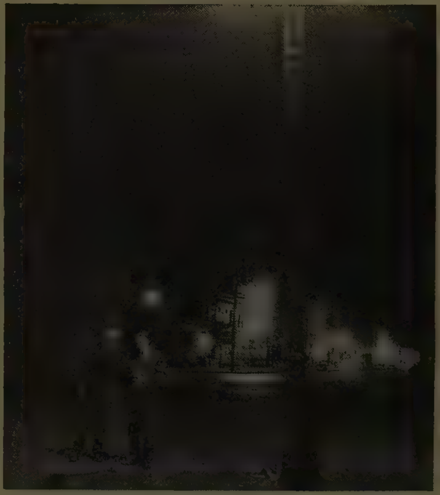
Engineers of the Arco Company, Cleveland, Ohio, manufacturers of industrial finishes and coatings, say that they have cut testing time and costs 80 per cent by using a General Electric Type B magnetic thickness gage for quality control.

Every Arco finish is designed to be applied at a specific thickness for the best possible adhesion. Because the thickness gage makes it possible to check and control thickness quickly and accurately, the G-E gage has become a vital part of their manufacturing process.

Arco Company also uses this gage to help determine the hardness of their paint. The standard Type B thickness gage has a range of 0.10 mils to 100 mils. Other instruments of this type with ranges from 0.10 mils to 300 mils can be furnished to measure the thickness of any non-magnetic material on a magnetic base.

CAPACITOR PEAK VOLTAGE in a jet-engine-ignition system is measured by a General Electric electrostatic voltmeter. It can measure peak voltages of critical ignition circuits without disturbing the ignition system itself.

SENSITIVE LIGHTMETER AIDS STUDY OF STREET LIGHTING FOR NIAGARA MOHAWK



Niagara Mohawk Power Corporation, Albany, N. Y. is currently using a G-E Type PF-13 sensitive lightmeter to aid its streetlighting surveys. "Because of its portability and high sensitivity, the PF-13 lightmeter enables us to check quickly and efficiently critical low-light intensities—both indoors and outdoors," reports Mr. C. E. Waldron, street-lighting advisor for Niagara Mohawk.

The Type PF-13 lightmeter, weighing only 14 pounds with carrying case, has its cell corrected for oblique angles of light by a cosine-corrected lens. With two ultra-sensitive ranges, 0-1 and 0-5 footcandles, streetlighting levels that before couldn't be determined without elaborate equipment are taken with ease.

In addition to use in utility-company surveys of street lighting, the meter is especially adaptable to surveys by law-enforcement, safety-lighting, and civic groups attempting to combat crime and to prevent motor-vehicle accidents through better lighting of streets and highways.

New "Radiation Monitor" Just Announced by G. E.

A new radiation detector, known as the "radiation monitor," has been announced by the General Electric Company. It is designed for the use of engineers, scientists, doctors, and technicians engaged in work where x-ray or gamma radiation is present. In addition, it may be a valuable tool for civilian defense radiation programs.

The monitor's high sensitivity detects much smaller amounts of gamma radiation than is permitted by the most stringent safety regulations. This sensitivity, coupled with continuously visible indication, quickly gives warning of a radiation hazard in areas where the monitor is placed.

Light weight (only fourteen ounces) adds to the convenience of the monitor. It's also small—about the size of a quart oil can. Since it has a self-contained power source, it can easily be moved about. Furthermore, it does not require tubes or batteries. Full-scale reading is from 0 to 20 milliroentgens: accuracy is plus or minus ten per cent. The monitor can be recharged by merely turning it upside down.

SECTION D602-206, GENERAL ELECTRIC
SCHENECTADY 5, N. Y.

Please send me the following bulletins:
Indicate:
✓ for reference only
✗ for planning on immediate project

☐ PF-13 Sensitive lightmeter (GEC-611)
☐ Type B Magnetic thickness gage (GEC-319)
☐ Radiation Monitor (GEC-778)
☐ Electrostatic Voltmeter (GEC-403)

NAME..........................
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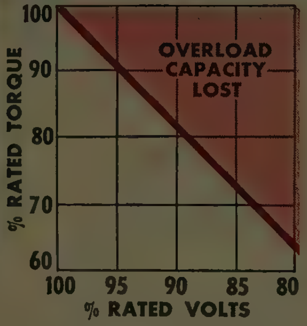
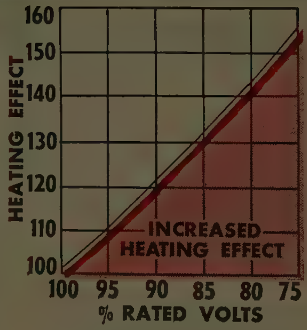
GENERAL ELECTRIC

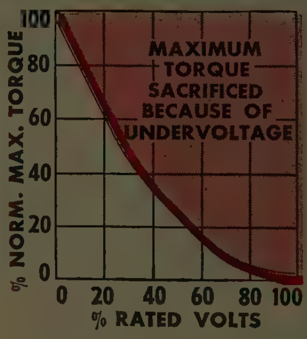
Time-Study



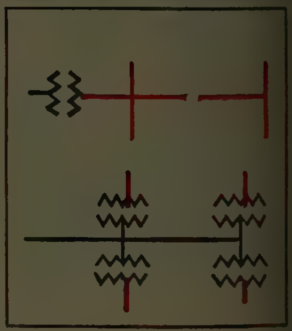
FULL PRODUCTION demands that rated voltage be maintained to all motors. Overload capacity, that extra push necessary for short intervals on many processes, falls off rapidly on undervoltage . . . falls approximately 10% for every 5% drop below rated voltage.



MOTORS BURN OUT quicker at undervoltage because of increased heating effect. Overload relays in the controls protecting your motors trip because of the extra current through them, open circuits to motors — cause machine down-time and production loss.

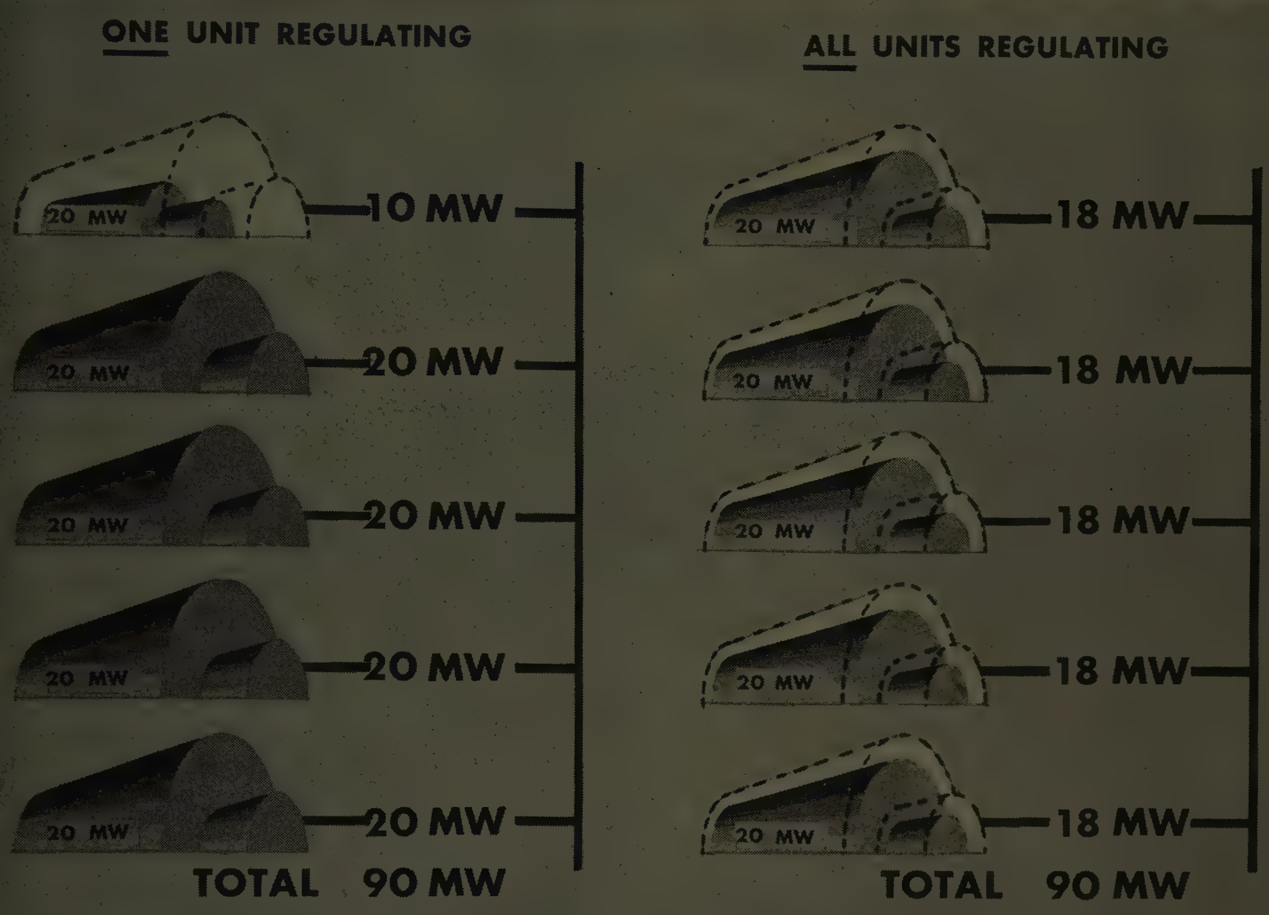


JOBS TAKE LONGER because torque and horsepower drop when voltage drops. Less torque means lighter cuts on lathes, shapers and other machine tools. More time must be spent to get the same job done. More overhead, more manhours must be figured into every job.



A MAJOR CAUSE of undervoltage is voltage drop in secondary feeders. Existing systems may not be adequate for new production schedules. Install A-C Substations at load centers to reduce line losses, cut feeder length, hold proper voltage, increase production.

How L&N Unit Load Control Cuts Effects of Load Changes



When one unit does all the regulating, a 10-MW change drops it to half load, at much reduced efficiency. If all units take part in regulation, this same 10-MW causes only a 2-MW drop on each. Economy stays high, and rate of load change on regulating units is reduced.

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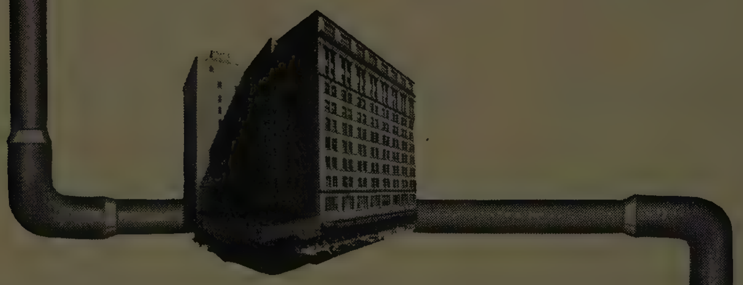

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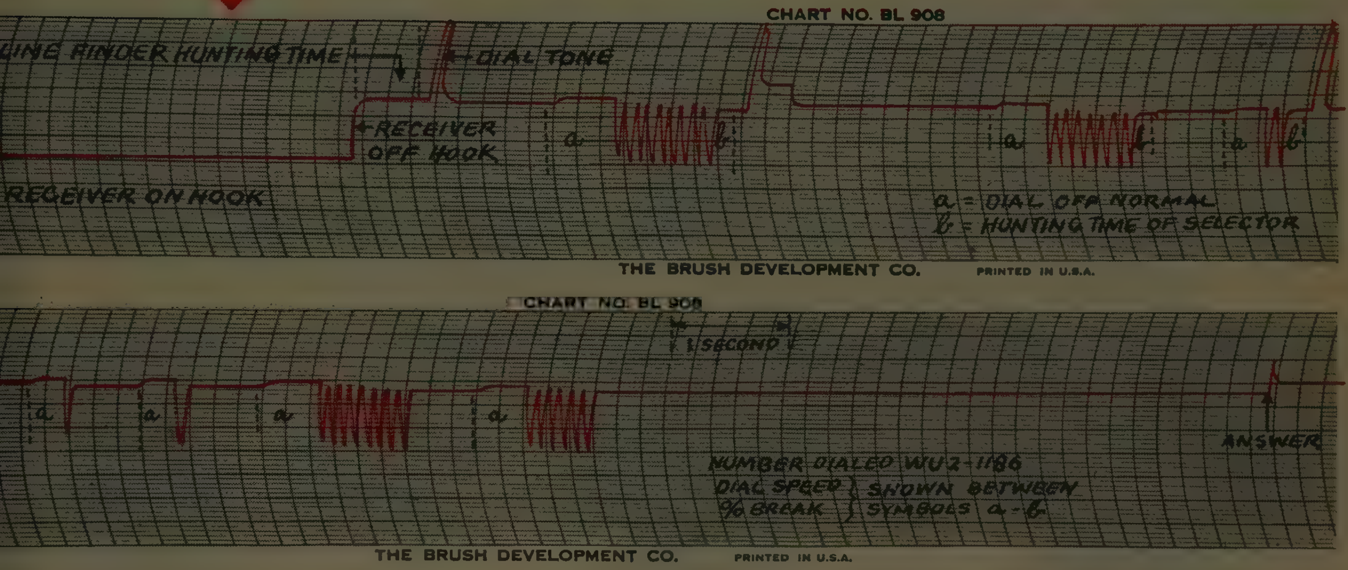

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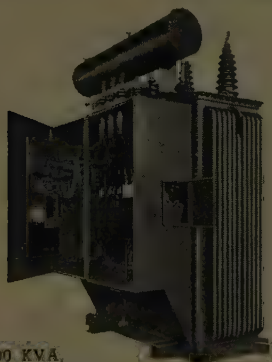
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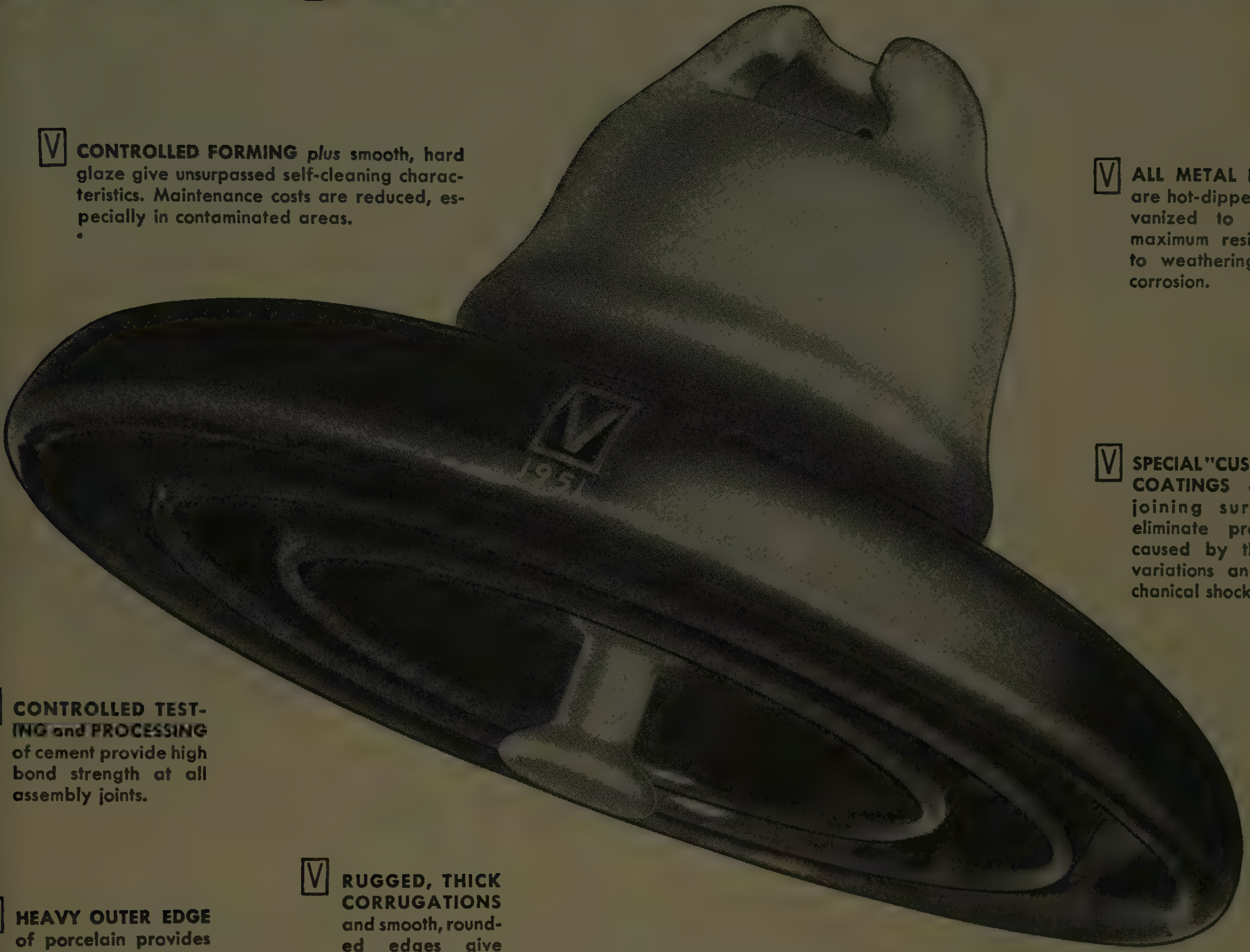

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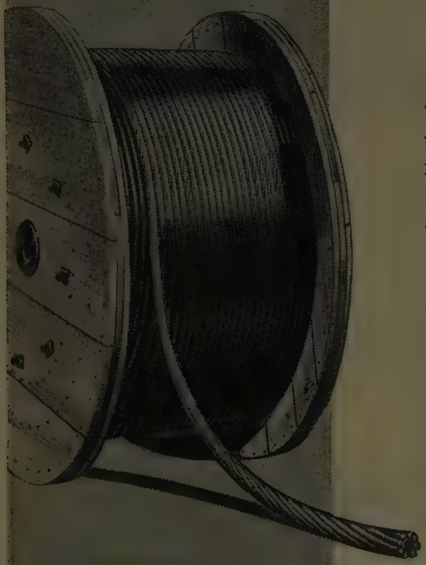

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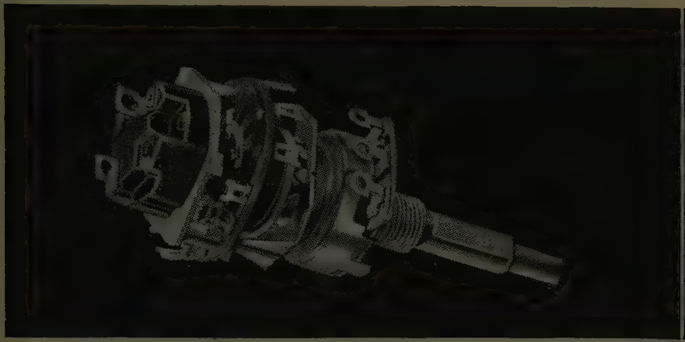

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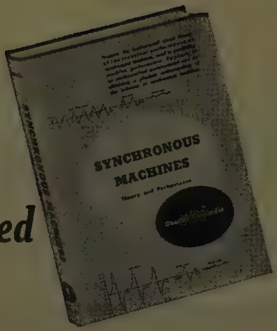

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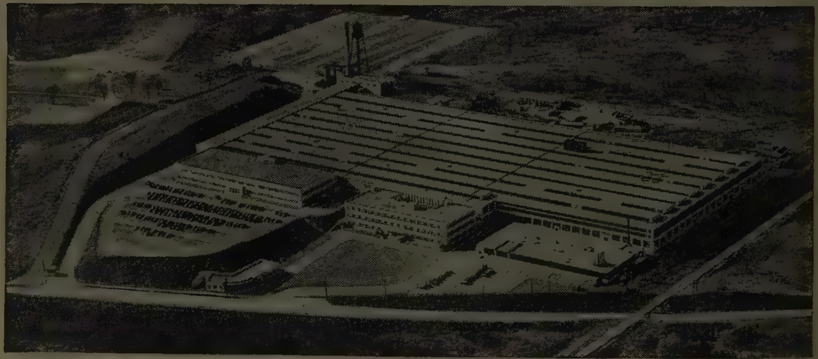

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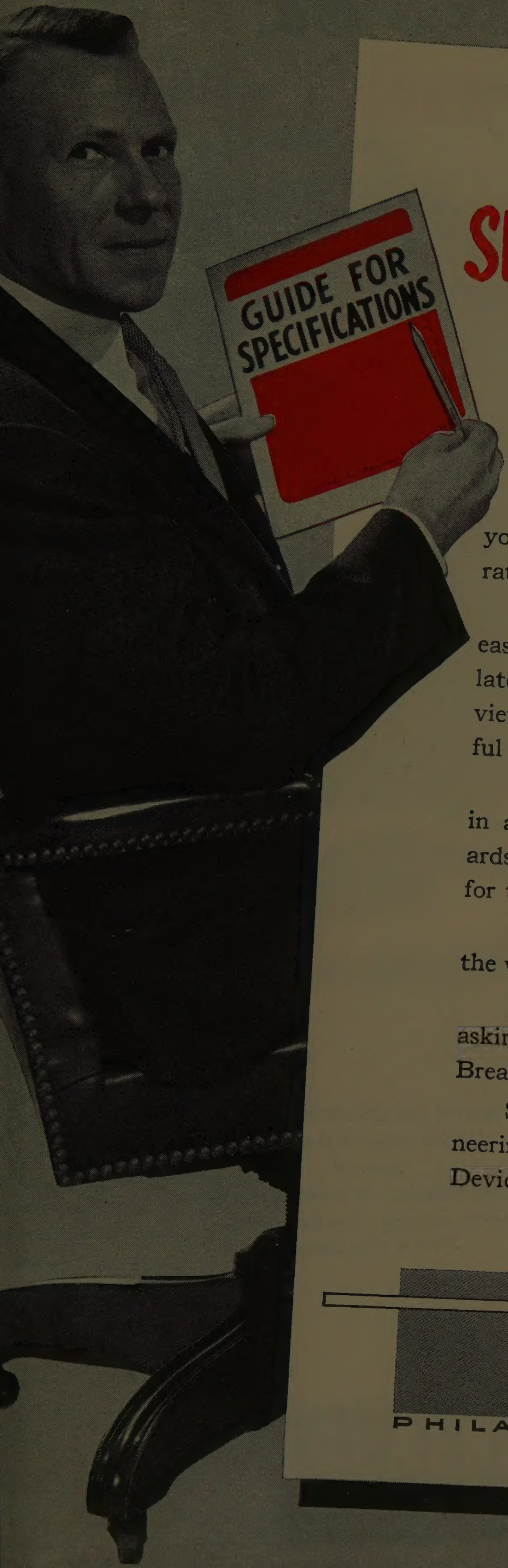

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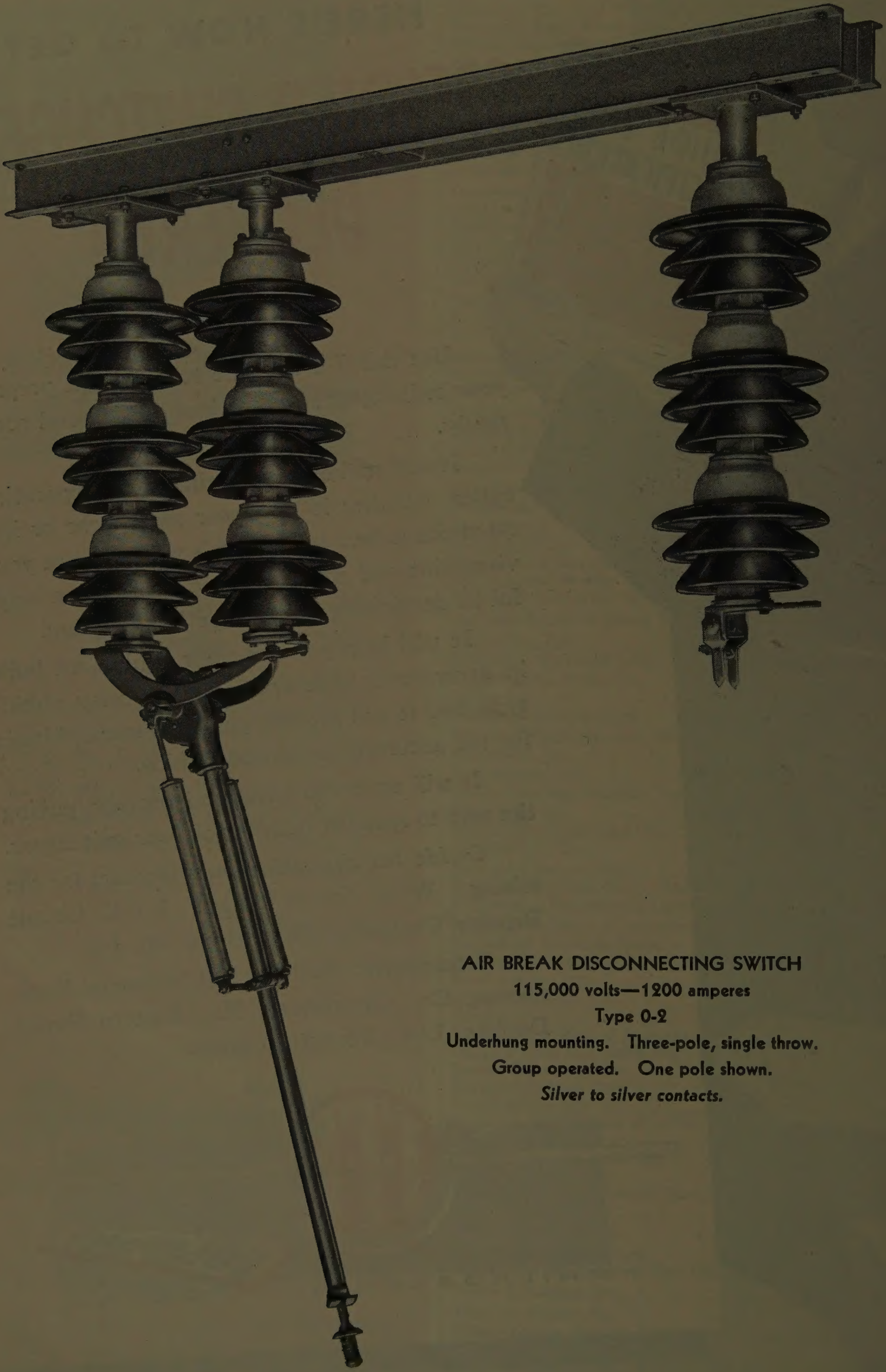

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Underhung mounting. Three-pole, single throw.
Group operated. One pole shown.
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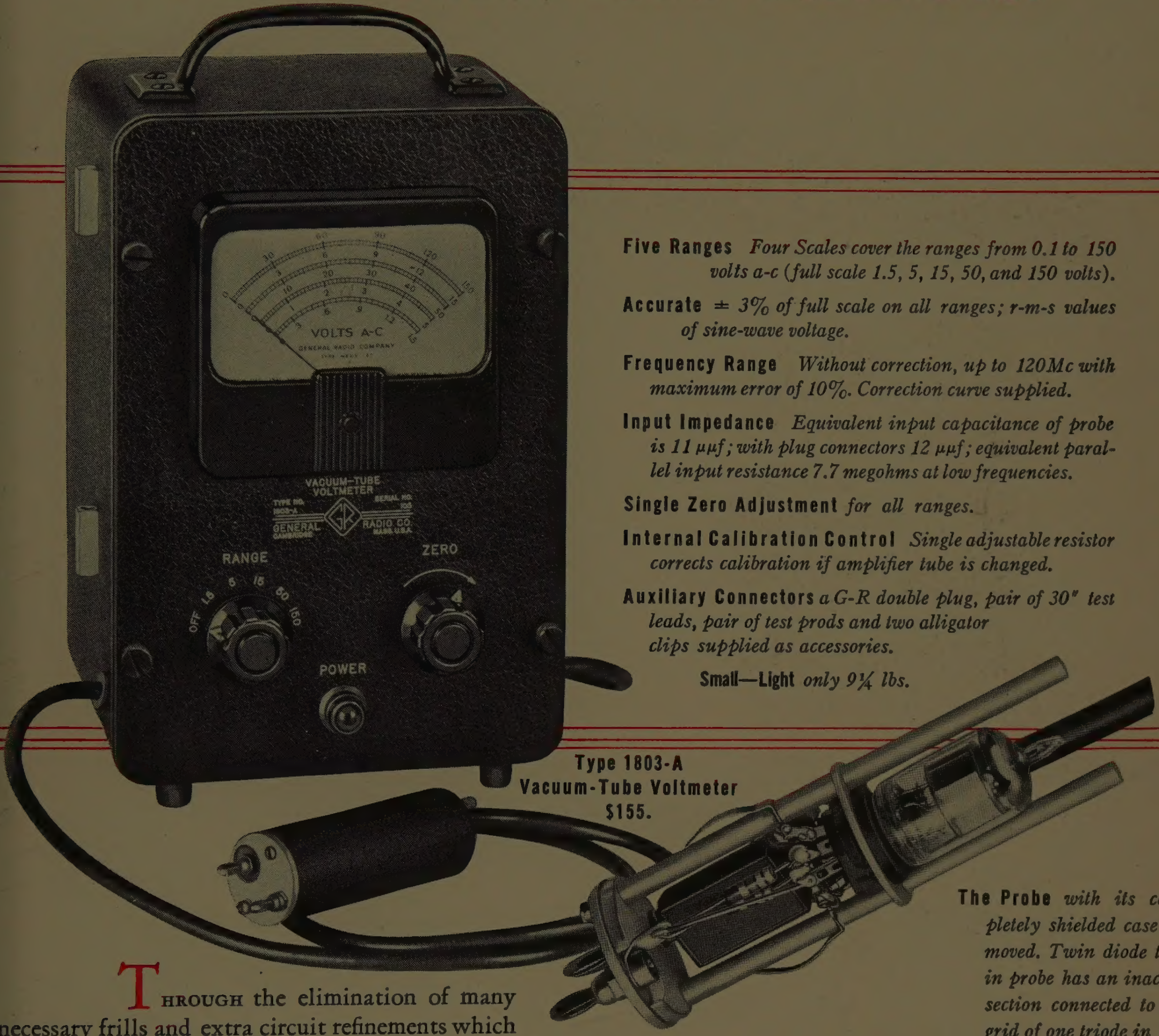

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